THE INFLUENCE OF FIXED-RATIO SCHEDULES OF REINFORCEMENT ON ACQUISITION AND RESISTANCE TO EXTINCTION OF THE INSTRUMENTALLY CONDITIONED GSR

By

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CHAPTER I

INTRODUCTION

The purpose of this study was to determine the influence of partial reinforcement upon the rate of emission of the unelicited GSR, a response mediated by the autonomic nervous system. Only recently has any evidence been reported to support the contention that autonomically mediated responses may be influenced by the presentation of reinforcement following their emission. The present study, thus, was intended to provide further empirical evidence on operant conditioning of the GSR and, hopefully, to relate operant conditioning of autonomic responses more fully to conventional operant conditioning.

Kimble (1961) distinguishes between two types of conditioning--classical and instrumental. He supports the distinction by indicating the possible differences between the two types of conditioning. Among the differences marshalled is the autonomic-classical and somatic-instrumental hypothesis. Kimble concluded, from the evidence he presents, that this distinction cannot be completely maintained on empirical grounds as some nonautonomic responses have been classically conditioned. His strongest statement on the matter, however, indicates that even though some skeletal responses have been classically modified, autonomically mediated behavior is not modifiable instrumentally: "Thus, for autonomically mediated behavior the evidence points unequivocally to

the conclusion that such responses can be modified by classical, but not instrumental training methods." (p. 100)

Furthermore, the efficacy of this technique, with autonomic responses, was questioned by Skinner, for he wrote, "Glands and smooth muscles do not naturally produce the kinds of consequences involved in operant reinforcement, and when we arrange such consequences experimentally, operant conditioning does not take place. We may reinforce a man with food whenever he 'turns red,' but we cannot in this way condition him to blush. . . ." (1953, p. 114) Skinner's belief, however, was based upon meager factual evidence.

The evidence

Mowrer (1938) attempted to make the GSR instrumental in a shock avoidance situation. His attempt ended in failure. In another experiment Skinner and Delabarre (Skinner, 1938) tried to condition vasoconstriction instrumentally. In this experiment a positive reinforcement was made contingent upon the response, but the authors reported no conclusive results. The Pavlovians (Kimble, 1961) simply have indicated that glandular responses cannot be conditioned instrumentally, without citing any data.

Recent studies

More recently, Mandler _et al_. (1962) attempted to influence the rate of occurrence of unelicited GSRs by rewarding the response with money, the earning of which was signalled by a light. They reported increased emission of GSRs for some of their _S_s. The results reported by Shearn (1960) are also somewhat equivocal. He attempted to condition

heart rate acceleration by making the criterion response instrumental in avoiding a shock. His results indicated that while the experimental group differed significantly from the control group in number of accelerations, there was no significant reduction in the number of shocks received. Harwood (1959, 1962) tried to condition heart rate deceleration by rewarding the criterion response. Although the results reported are not conclusive his research is continuing with improved instrumentation.

In contrast to the negative findings of Skinner and Delabarre (Skinner, 1938) reported above, Razran (1961) has reported a Russian study which showed instrumental conditioning of blood volume changes. In this study five human Ss were stimulated with painful electrical shock. This type of stimulation usually produces vasoconstriction, however, if vasodilation occurred the stimulus was terminated. When the Ss were allowed to observe their own photoplethysmographs (in real time) they learned to escape the shock.

In another study using an avoidance conditioning paradigm, Kimmel and Baxter (1964) found that an avoidance group gave superior performance when compared to partially reinforced classical controls with trace conditioning and the GSR.

In a series of experiments, Kimmel and his associates (Fowler and Kimmel, 1962; Kimmel and Hill, 1960; and Kimmel and Kimmel, 1963) have reported positive results with operant conditioning of the GSR. In the first of these studies, Kimmel and Hill (1960) found that the rate of the unelicited reinforced GSRs was influenced by operant training although the effect was not apparent until the reinforcement period was terminated. Using a dim white light as a reinforcer Fowler and Kimmel

(1962) attempted to determine whether the unelicited GSR could be conditioned instrumentally. These investigators found that the experimental groups receiving 16 min. of response-contingent training differed from the control group during acquisition and the early minutes of extinction. In addition, the relative response frequency trends during extinction between the two groups were opposite in direction, although this effect was not statistically significant. These results were interpreted as providing further support for the conclusion that the unelicited GSR can be conditioned operantly.

The essential aspects of the Fowler and Kimmel (1962) study were replicated by Kimmel and Kimmel (1963). In this study Ss were divided into two groups, Contingent and Noncontingent. Contingent Ss received a dim white light following each emitted GSR while Ss in the Noncontingent group received the light only when no GSRs were being emitted. The dim white light which served as the reinforcer was the sole source of visual stimulation. Each S in the Noncontingent group was "yoked" to an S in the Contingent group to receive the same number of visual stimuli per minute during the 16-min. training period. Following training, all Ss received 10 min. of extinction, during which time no lights were presented. Before the actual training period was begun, Ss were allowed to adapt to the experimental room for 10 min. This allowed the Ss to achieve a more stable response rate than was obtained in the earlier studies using shorter adaptation periods. Due to this longer adaptation period, considerable reduction in the amplitude of the emitted GSR was noted. Therefore, the criterion for counting responses and for presenting or not presenting the reinforcer was changed to include all responses

detectable by the naked eye. The grace period[1] following delivery of a reinforcer was changed from 5 sec. to 3 sec. to allow more responses to be counted. Kimmel and Kimmel's results indicated that the Contingent groups responded more frequently during acquisition than during the last 5 min. of adaptation (base level) while the Noncontingent group responded less frequently during the reinforcement period than they had previously. The large obtained differences in response frequencies between the two groups were statistically significant. During extinction the trends of the two groups were converging toward the level which had obtained during adaptation, thus indicating opposite trends. Both the Contingency and the Contingency X Minutes interaction effects were statistically significant during extinction.

The effect of partial reinforcement

The previous studies (Fowler and Kimmel, 1962; Kimmel and Hill, 1960; Kimmel and Kimmel, 1963; and Mandler *et al*., 1962), using the operant conditioning technique with the GSR, have reinforced every response. Other criteria for the delivery of reinforcement may be followed. For example, every other response may be reinforced, every tenth response may be reinforced, or almost any number of responses may be required of the organism before reinforcement is delivered. In addition to the procedure of requiring a set number of responses to occur before reinforcement is delivered the experimental arrangement may be designed so that the organism obtains a reinforcement after a certain time

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[1]A response *elicited* by the stimulus light was neither counted nor reinforced. Thus, any response occurring from 1 to 4 sec. following the light was in the grace period.

interval has passed, provided the criterion response occurs after the specified time period. The influence of such schedules of reinforcement has been studied in detail (Ferster and Skinner, 1957).

A few of the basic schedules of reinforcement are: (a) Fixed-ratio schedules, in which the reinforcement is delivered after the specified number of responses have occurred, (b) Variable-ratio schedules, in which the number of responses required for reinforcement varies from reinforcement to reinforcement about some mean value, (c) Fixed-interval schedules, in which reinforcement is delivered following the first response occurring at the end of some fixed-interval, (d) Variable-interval schedules, in which the period of time during which no reinforcement is available varies between reinforcements around some mean value. Each of these schedules results in performance curves peculiar to the schedule.

In the typical free operant instrumental conditioning paradigm (e.g., bar pressing) high rates of responding can be maintained when the number of responses required to obtain a reinforcement is very large. Skinner (1957) has reported high rates of responding even when the number of responses required for one reinforcement was as high as 900. Such schedules of reinforcement (in this case a fixed-ratio schedule) have been found to result in high stable response rates during training with much greater resistance to extinction than can be obtained with continuous reinforcement. For example, Mowrer and Jones (1945) found that rats trained to press a bar for food reward differed in resistance to extinction as a function of the schedule of reinforcement during acquisition. The greater the ratio of nonreinforced responses to reinforced responses, the greater the resistance to extinction.

Recently, Boren (1961) trained rats to bar press on several fixed-ratio schedules and found increasing response rates with the increasing fixed-ratios used. More simply, the greater the number of responses required for a reinforcement, the higher the rate of responding obtained. In addition, it was found that the number of responses emitted during extinction was approximately a linear increasing function of the fixed-ratio used during acquisition.

Both the Fowler and Kimmel (1962) and the Kimmel and Kimmel (1963) studies reported decreasing response rates during the reinforcement period for the Noncontingent Ss. Kimmel (1962) hypothesized that the Ss who were receiving the light when they were not responding (Noncontingent Ss) may have been learning not to respond. That is, those Ss were being reinforced for not making GSRs. Analysis of the stimulus conditions during the reinforcement period (by the present writer) of the Noncontingent group indicated that the Ss were being reinforced on a modified variable-interval schedule (modified because the mean interval changed from minute to minute depending upon the number of reinforcements delivered). Assuming that the hypothesized process of not-responding (not emitting GSRs) involves active inhibition, then reinforcing the inhibition would tend to increase the probability that inhibition would occur as reflected by decreased resoonding.

In the previous studies the number of lights delivered to a Noncontingent S for any given minute was determined by the number of lights received by the matched Contingent S for the particular minute in question. The E then delivered the light to the Noncontingent S unsystematically (varied the interval), but only when the S was not responding.

Assuming that this analysis is correct and that the Noncontingent groups were actually being reinforced for inhibiting the GSR on a modified variable-interval schedule, then predictions can be made regarding the behavior of the Noncontingent Ss in the present study.

Each Noncontingent S in the present study will be yoked to a Contingent S. The number and pattern of lights received by the Noncontingent Ss will be immediately determined by the Contingent Ss. Since there are three fixed-ratio schedules of reinforcement for the Contingent groups (100 percent, 66 2/3 percent, and 33 1/3 percent) the actual number of lights received by a Noncontingent S will vary according to the fixed-ratio schedule of the yoked-Contingent S. Thus, group 100NC receives the most lights, followed by group 66NC, and, then group 33NC. The number of lights received will determine the modified variable-interval schedule a particular Noncontingent S receives; the greater the number of lights the shorter the variable-interval.

Holland and Skinner (1961) report that a short variable-interval schedule resulted in higher response rates than a long variable-interval schedule. For example, when the variable-interval during which no reinforcement was available is long the organism tended to emit fewer responses during the interval than when the interval is shorter.

Assuming that group 100NC receives the shortest variable-interval schedule then this group should be reinforced more for inhibiting GSRs, and, thus respond the least (see Hypothesis 3).

Procedural differences of the present study

The present study employed procedures similar to those described by Kimmel (1962) with a few major changes. These differences were as follows:

1. All of the previous recent GSR studies were done utilizing a partially soundproofed room and recording and amplifying equipment different from that used in the present study. Although the over-all difference was quantitatively unknown it should be noted that the present recording and amplifying equipment was more sensitive, and was able to monitor and record from Ss with higher base resistance levels. In addition a double-walled Industrial Acoustic Chamber (IAC) was used in the present study, in place of the partial soundproofing of the previous laboratory.

2. The responses to be reinforced were automatically determined by a differential amplifier. The amplifier was adjusted by the E during the adaptation period so that it would reinforce all noticeable deflections of the GSR recorder pen (all responses greater than or equal to a 10 ohm drop activated the circuit). The higher reliability of the reinforcement apparatus coupled with the greater sensitivity of the equipment resulted in the reinforcement of a larger number of unelicited GSRs than in any previous study in the series.

3. A "true" yoked control procedure was utilized. In the previous studies each S was run separately, and the Noncontingent Ss received a reinforcement only when no GSRs were occurring. In the present study two Ss were run simultaneously. Under these conditions the yoked-control S received the same number and pattern of reinforcements at the

same time as the Contingent Ss. This important modification resulted in the delivery of a reinforcement to the Noncontingent S regardless of his ongoing GSR activity. Thus, Ss in the Noncontingent groups might receive the reinforcer when they were making a GSR or not, since delivery or nondelivery was completely determined by the behavior of the Ss in the Contingent group. This yoking procedure is essentially the same as that used by Moore and Gormezano (1961).

4. The period of extinction was increased to 16 min. Since it was expected that the resistance to extinction would be increased after partial reinforcement training, this increase was introduced to enhance the likelihood of detecting the effect.

5. The previous studies all utilized a 100 percent schedule of reinforcement. The present study used several different ratios of partial and continuous reinforcement to determine their effects.

6. Since the effects of prolonged absence of stimulation on the unelicited GSR were unknown for the present laboratory a special 0 percent group was run. The Ss in this group merely sat in the experimental chamber but received no stimulation.

Hypotheses

The major hypotheses concerned the effects of Contingency of reinforcement (Contingent vs. Noncontingent) and Schedules of reinforcement (100 percent, 66 2/3 percent, 33 1/3 percent, and 0 percent) upon the rate of emission of GSRs during the experimental sessions. The specific hypotheses were as follows:

1. The rate of occurrence of emitted GSRs will vary as a function of Contingency of reinforcement. The Contingent groups will emit a greater number of responses during acquisition and extinction.

2. Within the Contingent groups, the rate of unelicited GSRs will vary inversely with the percentage of reinforcement, both during acquisition and extinction. Thus, the highest rate of responding will be obtained in the 33 1/3 percent group, followed by the 66 2/3 percent group and 100 percent group, respectively. In addition, all of the Contingent groups will respond above the 100 percent base level during acquisition and extinction.

3. Within the Noncontingent groups, the rate of emission of unelicited GSRs will vary inversely with the schedule of reinforcement received by the yoked-Contingent <u>S</u>s. Thus, the ordering of groups will be the same as in Hypothesis 2, but by Hypothesis 1, the over-all rates of the Noncontingent groups will be lower than the Contingent groups.

4. During the extinction period the rate of GSR emission will tend to return to the 100 per cent level (base level). Thus, the Contingent groups will <u>decrease</u> responding, and the Noncontingent groups will <u>increase</u> responding during extinction.

5. The rate of unelicited GSRs in the 0 percent group will tend to stabilize and remain constant for the experimental session.

CHAPTER II

METHOD

Subjects

One hundred and five undergraduate students at the University of Florida, 63 men and 42 women, volunteered as Ss. Each S who served in the experiment was paid one dollar for participation.[2] Ss of the same sex were run in pairs and the proportion of males to females in each treatment was equal.

Instructions[3]

The Ss were instructed to relax, to remain as motionless as possible, but to remain awake and alert. An interview was conducted at the end of the experimental session to determine whether these instructions had been followed. If it was determined that an S had not followed instructions he/she and the yoked partner were rejected. Ss would be rejected due to experimenter error, equipment malfunction, or failure to follow instructions (sleeping, moving, closing the eyes, etc.).

Apparatus

A small, dim patch of white light (0.7 ft. candles), located in the direct line of sight approximately 30 in. in front of S, served as

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[2]This support was provided by grant MH 06060-2.

[3]See Appendix A for complete instructions.

the reinforcing stimulus. The experimental rooms were double-walled soundproofed IACs equipped with a padded chair, a small minibox housing the reinforcing light, and a speaker which served as an intercom and for communication with the S. The GSR was picked up as a DC resistance change from the palm and back of the S's left hand by 3/4 in. zinc electrodes. The electrodes were covered with small gauze patches saturated with zinc sulfate solution and were housed in lucite cups filled with saline electrode paste (Grings, 1954). The constant current through the S was 20 microamps. The control panel in an adjoining room contained two Biophysical GSR amplifiers, and Texas Instruments Co. Recti-Riters. The recorders were equipped with signal-magnet pens for recording the occurrence of the reinforcing stimulus. The circuit controlling the reinforcing stimulus contained a differential amplifier and a switching system for automatic delivery and programming of the stimulus. In addition a hold circuit prevented the delivery of the reinforcing stimulus more than one time in any ~~4~~ 3 sec. period (the grace period). A block diagram of the reinforcing system can be found in Appendix B.

Design

The basic experimental plan consisted of a 2 x 3 factorial design with 15 Ss assigned at random to each cell, with the restriction that each pair of Ss be of the same sex and the male/female ratio be constant between cells. Ss were run in pairs, one member being assigned to the Contingent group and one member to the Noncontingent group. The independent variables were percentage of reinforcement (100 percent, 66 2/3 percent, and 33 1/2 percent) and Contingency of reinforcement

(Contingent and Noncontingent). The reinforcing circuit was automatically activated by any response ($\geq$ 10 ohms) of the Contingent S and delivered to both members of a pair at the same time.

In addition, another group of 15 Ss was run under conditions of no stimulation (0 percent group), to determine the course of GSR emission without stimulation.

Procedure

The two Ss of a pair entered the laboratory via different doors and were seated in separate experimental chambers. The palm and back of each S's left hand were then cleaned by acetone and the GSR electrodes were attached and held in position by a rubber band. The overhead light was extinguished and the experimental chamber doors were closed placing each S in total darkness. The experimenter (E) then read the instructions over the intercom. The S's questions were answered by rereading the appropriate part of the instructions. During the entire experimental period the Ss were monitored auditorily to detect any noises due to movements (shuffling, changing position in the chair, etc.), sneezes, coughs, etc. which might produce a GSR. All GSRs so identified were not scored as responses.

After a brief interval, during which the instruments were checked and adjusted a 10-min. adaptation period was begun. At the conclusion of the 10-min. adaptation period, the 16-min. reinforcement period was begun. Responses made by Contingent Ss were passed through the differential amplifier which closed the circuit delivering reinforcements; the reinforcements were delivered to both Ss of a pair simultaneously. The

programming apparatus delivered reinforcements on a fixed-ratio schedule (i.e., 1:1, 2:3, and 1:3). The circuit was designed to deliver a reinforcement at the point at which the particular GSR had reached its maximum. The duration of the reinforcement was 1/10 sec.

Following the reinforcement period the Ss were given a 16-min. period of extinction during which no stimulation was given. At the conclusion of the extinction period, the electrodes were removed and the interview was conducted separately for each S.

Interview

Each S was asked, (a) "Did you have the impression at any time during the experiment that the occurrence of the light depended upon something you might have done?"[4] If the answer to question (a) was negative, the S was told to make the hypothetical assumption that his behavior controlled the light, and then he was asked, (b) "Can you now think of any possible connection between your behavior and the presence or absence of the light?" Only the data of Ss whose answers indicated that they had followed the instructions (particularly regarding movement) completely were used. Five Ss were rejected for failure to follow the instructions regarding movement.[5] The Ss were then thanked, given a

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[4]Three Ss, one from each Contingent group, indicated that they thought the light came on when they expected it. Examination of their records indicated that these Ss were near the mean of their respective groups.

[5]Three Contingent Ss in the 100 percent group were rejected for moving. Two Contingent Ss in the 33 1/3 percent group were rejected, one for moving, the other for deep and irregular breathing. The rejection of these Contingent Ss necessitated the rejection of their yoked controls; therefore, a total of 10 Ss were rejected.

chit exchangeable for one dollar, and instructed not to discuss the experiment with anyone. The Ss of a pair left the laboratory by the doors through which they had entered.

CHAPTER III

RESULTS

The primary performance measure was the number of responses emitted per minute during adaptation, acquisition, and extinction. A response was defined as any deflection of the GSR recorder pen which indicated at least a 10 ohm drop in resistance. The reliability of this measure was determined separately for the Contingent and Noncontingent groups. This was accomplished by having two judges (one of whom was the E) read an unsystematically selected minute from the record of each of the Ss in the main experiment. The second judge read the records "blindly," in that she did not know to which group a record belonged. The correlation (Pearson) between the readings of the two judges was calculated for each group and both indicated high reliability (Contingent, $r = .96$; Noncontingent, $r = .97$). Both of these correlation coefficients were significantly different from zero ($p < .001$) but not from each other. Only <u>unelicited</u> GSRs were counted, thus all responses beginning between 1 and 4 sec. after onset of the light were not scored. These criteria applied to all records regardless of the group to which they belonged.

The basic response frequency measures[6] were first grouped into blocks of 2-min. intervals to increase their stability. Then they were

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[6]Appendices C-I present the untransformed frequency scores for each of the 105 Ss in 2-min. blocks. Appendix J presents the Means and Standard Deviations of the untransformed frequency scores in 2-min. blocks for all groups.

transformed to $\sqrt{X+1}$ to overcome the skewness of their frequency distributions (Snedecor, 1956). The transformed measures were then expressed as percentages of the transform of the average of the last two 2-min. blocks of the 10-min. adaptation period. These transformations were done separately for each 2-min. block for each S.

The group performance curves during adaptation were expected to indicate declining relative response frequencies as adaptation progressed, as well as no differences in average frequency at the end of adaptation. The relative response frequency curves, shown in Fig. 1, indicate that the general trend of the curves is downward, as expected. Table 1 presents the means and standard deviations for the adaptation period for the transformed percent response frequencies in 2-min. blocks. An analysis of variance of these data indicated that only the Minutes effect was significant ($F = 7.02$, $df = 4/334$, $p < .001$).[7] This significant effect, in conjunction with the shape of the curves in Fig. 1, indicated a significant adaptation trend.

The response frequencies during the last 4 min. of adaptation were examined for each of the seven groups. It was necessary that these pretraining frequencies be comparable between groups so that any differences found after training could be attributed to the experimental treatment and not to sampling errors. The average response frequencies (and SDs) during the last two 2-min. blocks of adaptation transformed to

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[7]For one pair of Ss the recording apparatus was not started until the beginning of the third minute of adaptation. Thus, 2 missing data were replaced and 2 df were subtracted from the error term.

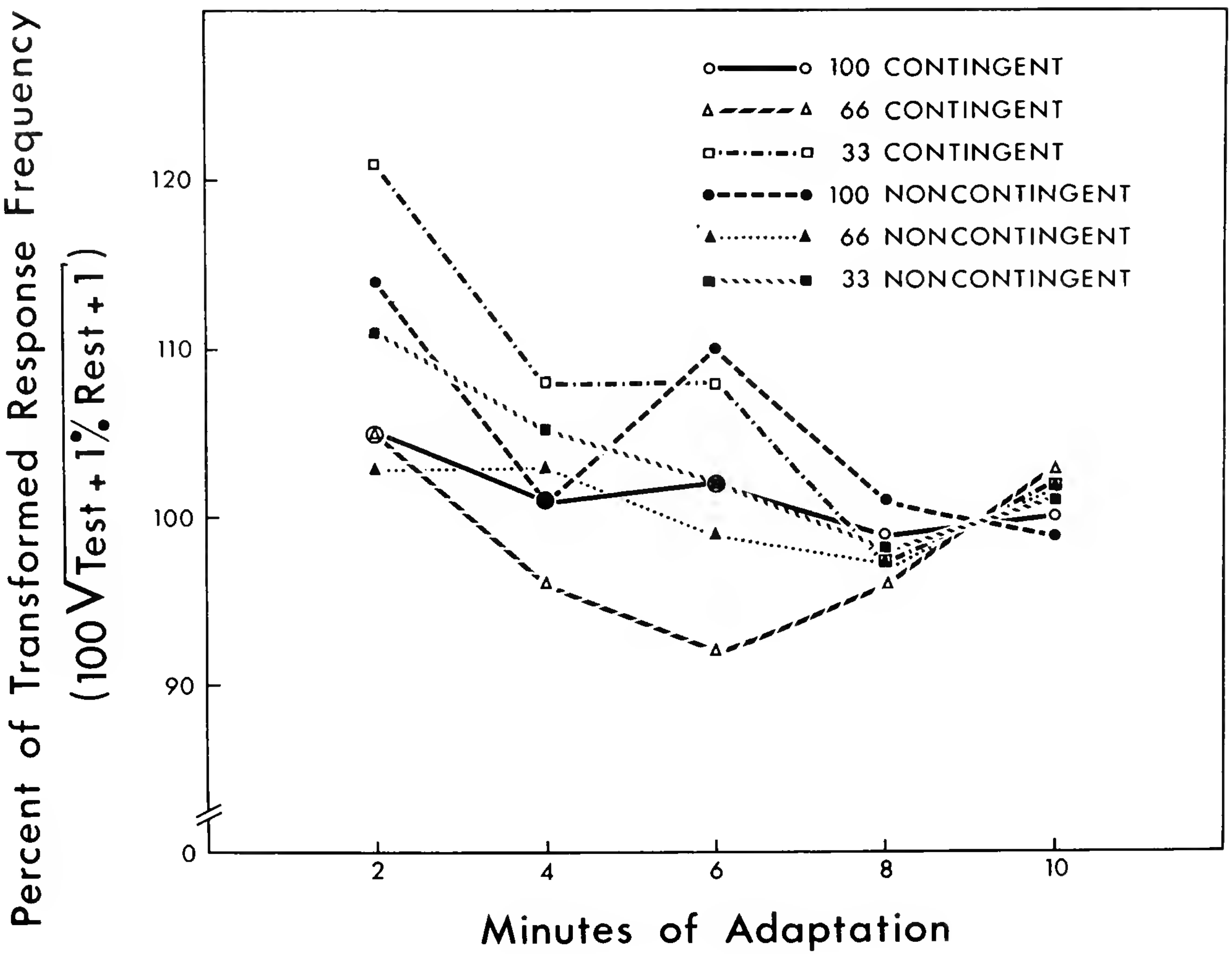

Fig. 1.--Percentage of transformed response frequencies during the 10-min. adaptation period in 2-min. blocks for the Contingent and Noncontingent groups.

TABLE I

MEANS AND STANDARD DEVIATIONS OF TRANSFORMED PERCENT RESPONSE FREQUENCIES OF EACH CONTINGENCY AND RATIO OF REINFORCEMENT GROUP DURING ADAPTATION (IN 2-MIN. BLOCKS)

Group		Adaptation 1	2	3	4	5
Contingent						
100	$\bar{X}$	105	101	102	99	100
	SD	33.6	26.3	27.2	11.0	11.9
66	$\bar{X}$	105	96	92	96	103
	SD	23.2	13.7	17.9	7.5	6.7
33	$\bar{X}$	121	108	108	97	102
	SD	25.2	13.8	19.3	11.8	10.9
Noncontingent						
100	$\bar{X}$	114	101	110	101	99
	SD	28.7	11.5	23.6	7.2	7.7
66	$\bar{X}$	103	103	99	97	102
	SD	20.0	12.0	14.5	5.9	5.4
33	$\bar{X}$	111	105	102	98	101
	SD	23.9	18.3	13.2	9.6	9.3

$\sqrt{X+1}$ for all groups are shown in Table 2. Analysis of variance indicated no significant differences among the groups ($F < 1$, df = 6/98).

To compare the effect of the reinforcer on the different Contingent and Noncontingent groups during acquisition and extinction, the performance curves for the different groups were plotted in 2-min. blocks for the 16 min. of acquisition and extinction. Figs. 2, 3, and 4 present these curves.

<u>Acquisition</u>

The first section of Fig. 2 shows the combined performance curve of the three Contingent groups and of the combined yoked Noncontingent controls during the 16 min. of acquisition. Inspection of these curves reveals that the over-all mean of the Contingent (95.83 percent) was higher than that of the Noncontingent groups (88.33 percent). Further examination of the acquisition curves indicates that the over-all difference between the Contingent and Noncontingent groups became larger during reinforcement.

To evaluate the statistical significance of these differences the data obtained during acquisition were subjected to an analysis of variance. Table 3 presents the means and standard deviations for the 90 <u>S</u>s of these groups for the 16 min. of reinforcement, and Table 4 summarizes the analysis of variance. The analysis indicated that the difference between Contingent and Noncontingent groups were statistically significant ($F = 6.23$, df = 1/84, $p < .025$). No other differences were found to be significant.

TABLE 2

MEANS AND STANDARD DEVIATIONS OF $\sqrt{X+1}$, WHERE X IS THE AVERAGE OF THE LAST TWO 2-MIN. BLOCKS OF ADAPTATION, FOR EACH SUBJECT

Group	Mean	Standard Deviation
Contingent		
100	3.33	0.82
66	3.29	0.72
33	3.06	0.76
Noncontingent		
100	3.31	1.04
66	3.30	0.68
33	3.36	0.68
0% control	3.15	0.76

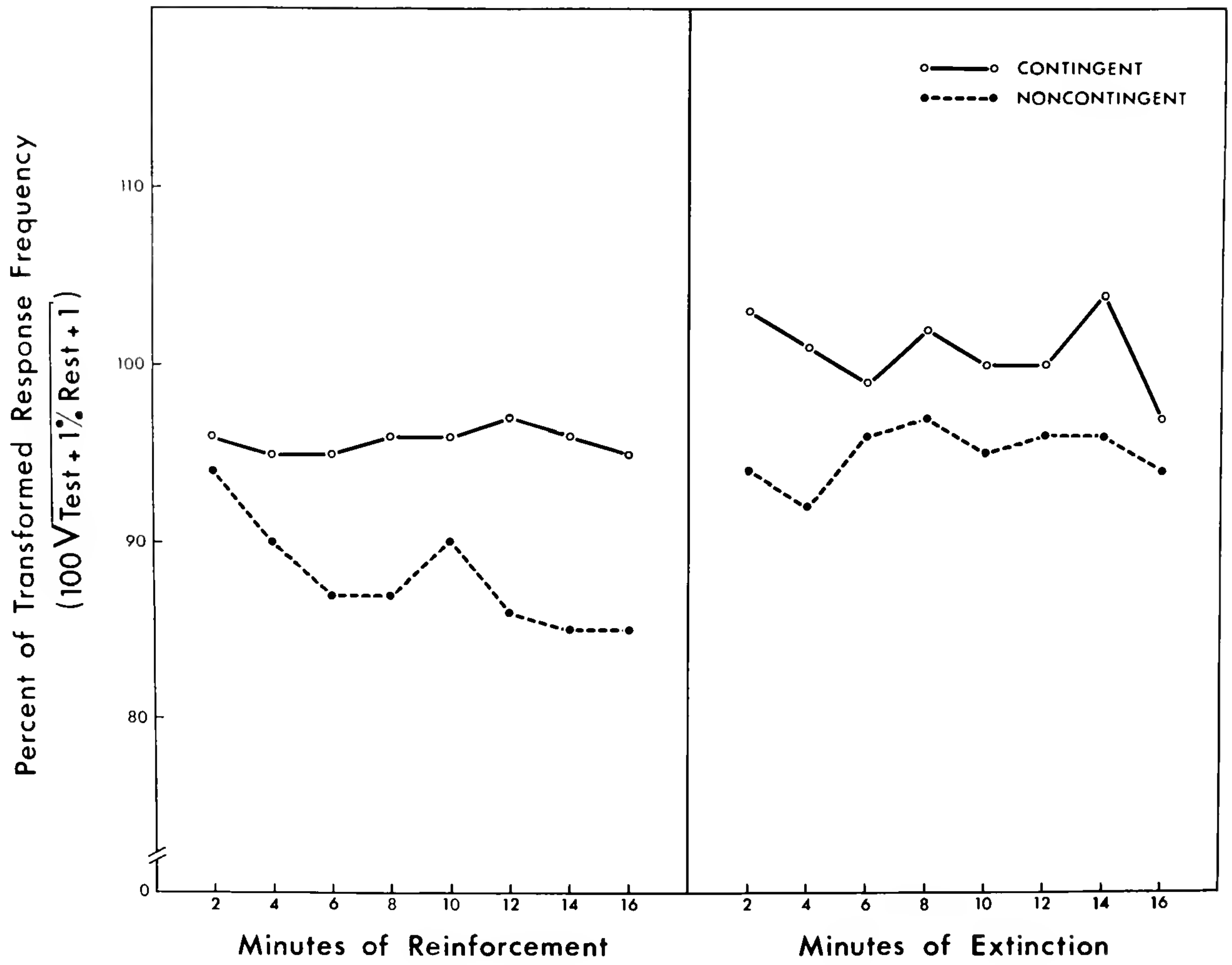

Fig. 2.--Percentage of transformed response frequencies during the 16 min. of reinforcement and the 16 min. of extinction for the combined Contingent and combined Noncontingent groups.

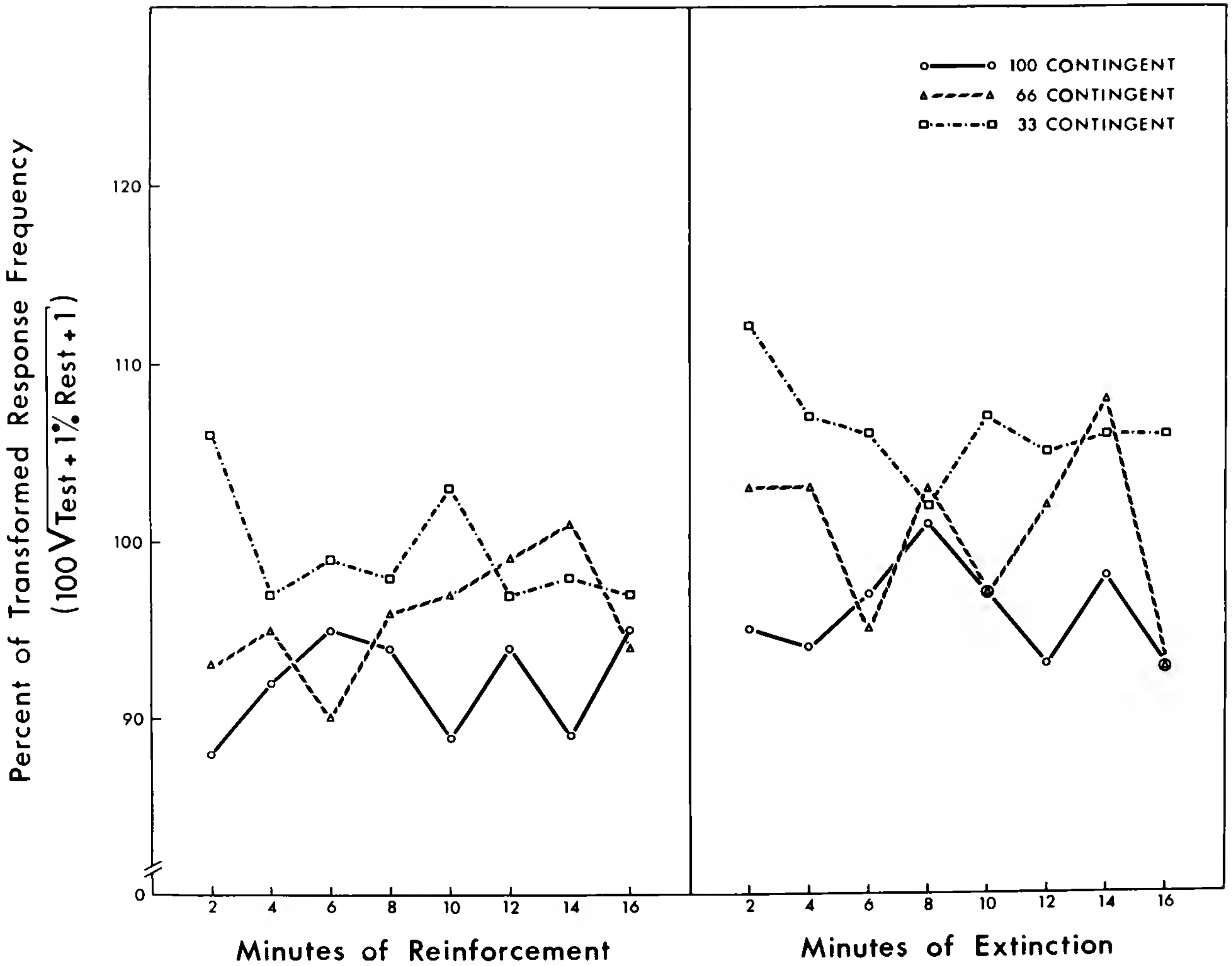

Fig. 3.--Percentage of transformed response frequencies during the 16 min. of reinforcement and the 16 min. of extinction for the Contingent groups.

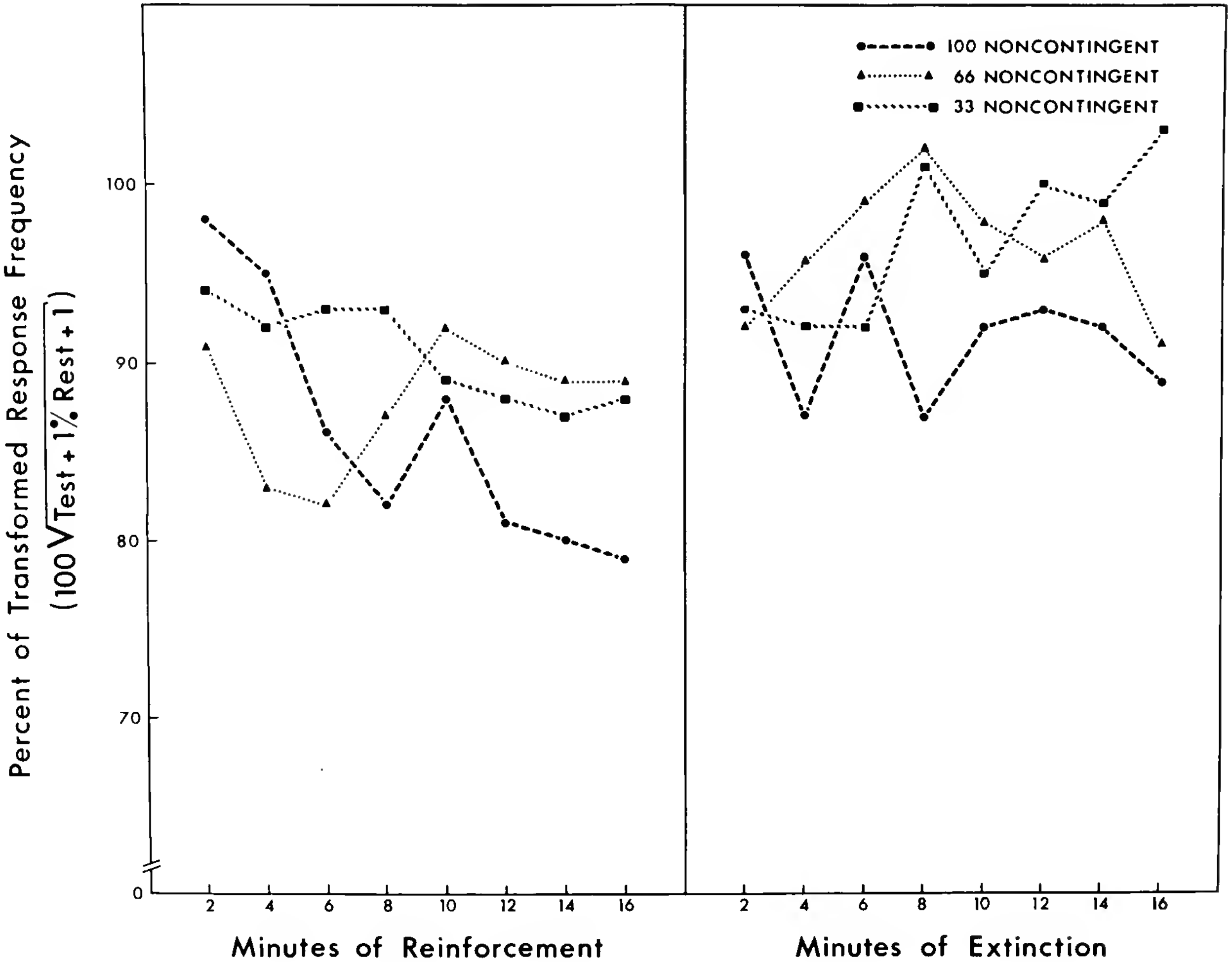

Fig. 4.--Percentage of transformed response frequencies during the 16 min. of reinforcement and 16 min. of extinction for the Noncontingent groups.

TABLE 3

MEANS AND STANDARD DEVIATIONS OF TRANSFORMED PERCENT RESPONSE FREQUENCIES OF EACH CONTINGENCY AND RATIO OF REINFORCEMENT GROUP DURING ACQUISITION (IN 2-MIN. BLOCKS)

Group		Acquisition 1	2	3	4	5	6	7	8
Contingent									
100	$\bar{X}$	88	92	95	94	89	94	89	95
	SD	22.4	25.5	20.2	14.6	12.1	14.2	16.1	13.7
66	$\bar{X}$	93	95	90	96	97	99	101	94
	SD	11.0	1.28	14.1	15.9	20.0	18.8	16.0	21.8
33	$\bar{X}$	106	97	99	98	103	97	98	97
	SD	16.0	15.7	19.4	13.9	24.9	21.9	23.5	20.9
Noncontingent									
100	$\bar{X}$	98	95	86	82	88	81	80	79
	SD	37.9	34.7	26.0	14.4	13.6	24.0	20.3	27.9
66	$\bar{X}$	91	83	82	87	92	90	89	89
	SD	15.3	16.1	19.9	20.4	16.4	17.8	18.4	17.7
33	$\bar{X}$	94	92	93	93	89	88	87	88
	SD	17.4	9.5	14.6	16.9	20.7	24.8	22.1	19.9

TABLE 4

SUMMARY OF ANALYSIS OF VARIANCE OF TRANSFORMED PERCENT RESPONSE FREQUENCIES DURING THE 16 MIN. OF ACQUISITION (IN 2-MIN. BLOCKS)

Source	df	MS	F
(Between Ss)	(89)	1,700.33	-
Contingency	1	10,132.50	6.23*
Ratio	2	2,164.46	1.08
C x R	2	151.83	-
Error (b)	84	1,625.76	
(Within Ss)	(630)	247.14	-
Minutes	7	214.29	-
M x C	7	233.55	-
M x R	14	279.79	1.13
M x C x R	14	260.02	1.05
Error (w)	588	246.78	

*$p < .025$.

Fig. 3 indicates that the differences among the Contingent groups were greatest during the first 2-min. block of reinforcement. These differences oscillated and became smaller as the number of reinforcements increased, until, at the end of reinforcement, there was almost no difference among these three groups.

To evaluate this trend, the data for the Contingent groups were subjected to an additional separate analysis. Although this analysis indicated no significant over-all F ratios, t tests on the first block of 2 min. showed the response rate of the 33C group to be significantly greater than that of the 66C and 100C groups ($t = 1.93$, $p < .05$, and $t = 2.68$, $p < .025$, respectively).

These comparisons tend to support the observation that the largest differences among the Contingent groups occurred during the first 2-min. block of acquisition.

Several facts about the data suggested that the linear component of the acquisition trend in the Contingent groups be examined. The 33C group's mean performance during the first 2-min. block was about 100 percent, while both the 66C and 100C were below 100 percent. Secondly, the over-all curves of the two groups that were below 100 percent at the beginning of acquisition appeared to increase slightly as training progressed while the 33C group appeared to decrease. It was clear that the slopes of the 100C and 66C groups were positive while that of the 33C group was negative. The differences among the linear components of these trends were significant ($F = 8.91$, $df = 2/42$, $p < .001$),[8] thus

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[8]The error term used in this analysis is the partitioned error term suggested by Grant (1956) and more recently by Gaito and Turner (1963).

establishing the statistical reliability of the apparent convergence of the Contingent groups during training.

Contrasted to the behavior of the Contingent groups, were the performance curves of the Noncontingent groups. Fig. 4 indicates that the tendency of these three groups was toward <u>fewer</u> responses as training progressed. No statistically significant differences in linear trend were present in these data nor was their over-all trend significantly negative.

<u>Extinction</u>

The second half of Fig. 3 and the second half of Fig. 4 show the transformed response frequency curves for each Contingent and Noncontingent group, respectively, for the extinction period, in 2-min. blocks. The means and standard deviations of these data are presented in Table 5.

The first thing to be observed in the extinction data is the general convergence of the groups. By the end of the first 8 min. of extinction, the differences that were present at the end of training had almost entirely disappeared, with the exception of group 100NC, which fluctuated greatly. Furthermore, the only group that remained consistently above the base level of 100 percent was group 33C. Of special interest was the behavior of the Contingent groups as compared to the Noncontingent groups during the first 2 min. of extinction. The Contingent groups separated considerably from each other, while the differences present during the last 2 min. of acquisition for the Noncontingent groups almost entirely disappeared during the first 2-min. block of extinction. These changes were not statistically significant.

TABLE 5

MEANS AND STANDARD DEVIATIONS OF TRANSFORMED PERCENT RESPONSE FREQUENCIES OF EACH CONTINGENCY AND RATIO OF REINFORCEMENT GROUP DURING EXTINCTION (IN 2-MIN. BLOCKS)

Group		Extinction 1	2	3	4	5	6	7	8
Contingent									
100	$\bar{X}$	95	94	97	101	97	93	98	93
	SD	13.7	15.4	10.2	17.5	8.4	18.7	36.0	17.5
66	$\bar{X}$	103	103	95	103	97	102	108	93
	SD	25.0	20.6	26.5	21.3	17.5	22.1	23.6	25.5
33	$\bar{X}$	112	107	106	102	107	105	106	106
	SD	32.7	34.6	28.0	25.6	32.4	26.8	22.3	28.8
Noncontingent									
100	$\bar{X}$	96	87	97	87	92	93	92	89
	SD	24.7	17.9	20.0	17.4	26.8	26.1	22.1	22.7
66	$\bar{X}$	92	96	99	102	98	96	98	91
	SD	19.3	19.9	21.2	23.6	15.8	19.8	46.0	23.8
33	$\bar{X}$	93	92	92	101	95	100	99	103
	SD	15.7	25.5	20.3	22.3	25.2	22.0	20.9	18.7

An analysis of variance was carried out on the data from the first 8 min. of extinction and is presented in Table 6. The analysis showed several things. First (see Table 5), extinction[9] occurred to a sufficient extent that the over-all difference due to Contingency of reinforcement was not significant. Secondly, the Minutes X Contingency interaction was not significant, indicating again the extent to which extinction mitigated against significant group differences (see the significant modified Minutes X Contingency interaction below). To evaluate possible differences which occurred early in the extinction period but soon disappeared, analysis of variance was carried out on the data of the first 2-min. block of extinction. In this analysis the Contingency effect resulted in an F ratio of 3.81 ($df = 1/84$, $p < .10$). Further breakdown of the data during the first 2-min. block was performed by ranking the means and carrying out Duncan's Range test (1955).[10] This test indicated that the mean of group 33C was significantly different from the mean of the 66NC group ($p < .05$). Analysis of the data of the second 2-min. block of extinction indicated that the 33C group was significantly greater than the 100NC group.

Since the differences between the means of groups 100C and 100NC fluctuated widely during the first 8 min. of extinction, these two groups were set aside and another analysis was performed on the remaining four groups: 66C, 66NC, 33C, and 33NC. Analysis of variance on the

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[9] By "extinction" is meant "return to pretraining response level." For the Noncontingent groups this means <u>increasing</u>, while for the Contingent groups it means <u>decreasing</u>.

[10] For the rationale behind such a test after obtaining a nonsignificant F see Edwards (1960).

TABLE 6

SUMMARY OF ANALYSIS OF VARIANCE OF TRANSFORMED PERCENT RESPONSE FREQUENCIES DURING THE FIRST 8 MIN. OF EXTINCTION (IN 2-MIN. BLOCKS)

Source	df	MS	F
(Between Ss)	(89)	1,551.75	-
Contingency	1	4,319.47	2.80
Ratio	2	1,304.72	-
C x R	2	694.03	-
Error (b)	84	1,545.10	
(Within Ss)	(270)	199.44	-
Minutes	3	153.74	-
M x C	3	261.46	1.35
M x R	6	181.77	-
M x C x R	6	459.07	2.37*
Error (w)	252	193.48	

*$p < .05$.

data from these four groups during the first 8-min. of extinction resulted in a significant Contingency x Minutes interaction ($F = 3.05$, $df = 3/168$, $p < .05$). This significant interaction indicated the convergence of these groups over minutes. Both Contingent groups decreased responding, and both Noncontingent groups increased responding.

Table 6 shows that the Minutes X Contingency X Ratio effect was significant ($F = 2.37$, $df = 6/252$, $p < .05$). This interaction may be clarified by examination of Figs. 3 and 4. The performance curves indicate that the differences between groups 33C, 33NC, and the differences between groups 66C, 66NC appear to have become smaller while the differences between groups 100C and 100NC fluctuated. Further analysis of this significant interaction was accomplished by analyzing the trend of the data for the first 8 min. of extinction. Table 7 presents the results of this analysis. A significant Contingency X Ratio linear component was found ($F = 3.41$, $df = 2/84$, $p < .05$). This effect resulted largely from the fact that the difference between the linear extinction trends of the 33C and 33NC groups was significant ($F = 4.32$, $df = 1/84$, $p < .05$). The triple interaction of Table 6 was probably significant because of the convergence of groups 33C and 33NC, the partial convergence of groups 66C and 66NC, and the considerable fluctuation between groups 100C and 100NC.

0 percent control group

It was hypothesized that the Ss comprising the no stimulation group, who merely sat in the experimental chamber, would adapt to the situation and then stabilize (indicated by an initial decrease in

TABLE 7

SUMMARY OF ANALYSIS OF VARIANCE OF LINEAR TREND OF TRANSFORMED PERCENT RESPONSE FREQUENCIES DURING THE FIRST 8 MIN. OF EXTINCTION (IN 2-MIN. BLOCKS)

Source	df	MS	F
(Groups)	(5)	499.90	-
Contingency	1	441.10	1.62
Ratio	2	98.64	-
C x R	2	930.56	3.41*
Error (w, linear)	84	272.60	

*$p < .05$.

relative response frequency followed by fairly constant responding). Table 8 presents the means and standard deviations of the transformed response percentages in blocks of 2 min. for the 15 Ss in this group. The data of the 0 percent group are presented in the same time divisions as the earlier data (10-min. adaptation, 16-min. acquisition, 16-min extinction). Table 8 indicates an immediate decrease in responding during the first 8 min. followed by a slight increase during the next 2-min. block. During the next 16-min. period (comparable to the acquisition period) the mean percentage responding remained approximately constant at a little above the 100 percent base line and then decreased below this base line toward the end of the period. The last 16 min. (comparable to the extinction period) were marked by a general decrease after a slight initial increase in responding.

Statistical analysis of the first 10-min. period (adaptation) indicated that the variation of the means of the five 2-min. blocks was statistically significant ($F = 2.64$, $df = 4/56$, $p < .05$). This finding, in conjunction with the means shown in Table 8, indicated that adaptation did occur during the first 10 min. Analysis of the variation of the 2-min. means from minutes 11-26 and minutes 27-42 showed no significant differences, indicating that the subjects had more or less stabilized.

Another indication of the effect of the reinforcing stimulus was obtained by comparing the 0 percent control group to all other groups in the main experiment during acquisition and extinction. Examination of Figs. 2, 3, 4, and Table 8 shows that, after the first 2-min. block of acquisition, the 0 percent control group responded at a higher level of

TABLE 8

MEANS AND STANDARD DEVIATIONS OF TRANSFORMED PERCENT RESPONSE FREQUENCIES FOR THE 0 PERCENT CONTROL GROUP DURING THE 42-MIN. SESSION (IN 2-MIN. BLOCKS)

Minutes		1	2	3	4	5	6	7	8
1-10	$\bar{X}$	111	103	100	96	103	-	-	-
	SD	17.4	16.6	11.4	9.3	8.6	-	-	-
11-26	$\bar{X}$	101	106	104	106	107	102	96	100
	SD	16.4	16.8	20.4	17.5	17.4	20.7	17.6	17.6
27-42	$\bar{X}$	101	104	103	98	95	99	100	93
	SD	23.9	23.3	17.7	23.6	23.3	28.4	29.1	20.8

relative response frequency than all the other groups until the 14th minute. However, the 0 percent Control group gradually gave fewer and fewer responses while the Contingent groups were either gradually giving more responses or remaining about the same; all of the Noncontingent groups were gradually decreasing.

Analyses of variance carried out on these data indicated that the 0 percent Control group gave significantly more responses during acquisition than: (a) 100C group ($F = 5.58$, $df = 1/28$, $p < .05$), (b) 100NC group ($F = 7.61$, $df = 1/28$, $p < .025$), (c) 66NC group ($F = 10.20$, $df = 1/28$, $p < .005$), and (d) 33NC group ($F = 5.36$, $df = 1/28$, $p < .025$).

During extinction the 0 percent control continued to decrease responding gradually. For the first 6 min. of extinction the 0 percent control group's response level was equal to or above all the groups except group 33C. (Group 33C responded consistently above all other groups throughout extinction.) For the remainder of the extinction period the 0 percent control responded consistently below or equal to all groups except 100NC.

Small and large emitted GSRs

It was expected that the relative response frequencies for the Contingent groups would be above the 100 percent (pretraining) level during the reinforcement period. Fig. 3 shows that the opposite occurred. In general, all of the Contingent groups responded below their own preliminary levels.

There was the possibility that the sensitivity of the equipment used in the present study resulted in recording and reinforcing of very small responses which may not have been conditionable.[11] Lacey and Lacey (1958) have pointed out that some GSR activity is fairly stable over time and is not correlated with environmental stimulation. If these responses are actually not conditionable, then their "reinforcement" and inclusion in the frequency count for determination of the present dependent variable would contaminate the "true" conditioning effects. To examine this possibility the total response frequency was dichotomized into those responses greater than or equal to 1 percent of the base resistance of the S at the time a response occurred (large responses), and those responses less than 1 percent of the base resistance (small responses).[12] Base resistance in this case was defined as the resistance (in Kilohms) of the S. Each S's base resistance was obtained for each minute of the experimental session and small and large responses were measured and tabulated accordingly. These were then transformed and expressed as percentages of the number of responses during the last 4 min. of the adaptation period. These transformations were carried out on the data for all Ss separately and the results for the 100C and 100NC groups are presented in Fig. 5 (large) and Fig. 6 (small) in blocks of 2 min. The first half of Fig. 5 (large responses) indicates that the 100C group responded consistently above the 100 percent base level for the

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[11]The reason these small responses may not be subject to conditioning by instrumental methods will be dealt with in the discussion section.

[12]Kimmel (SEPA, 1964).

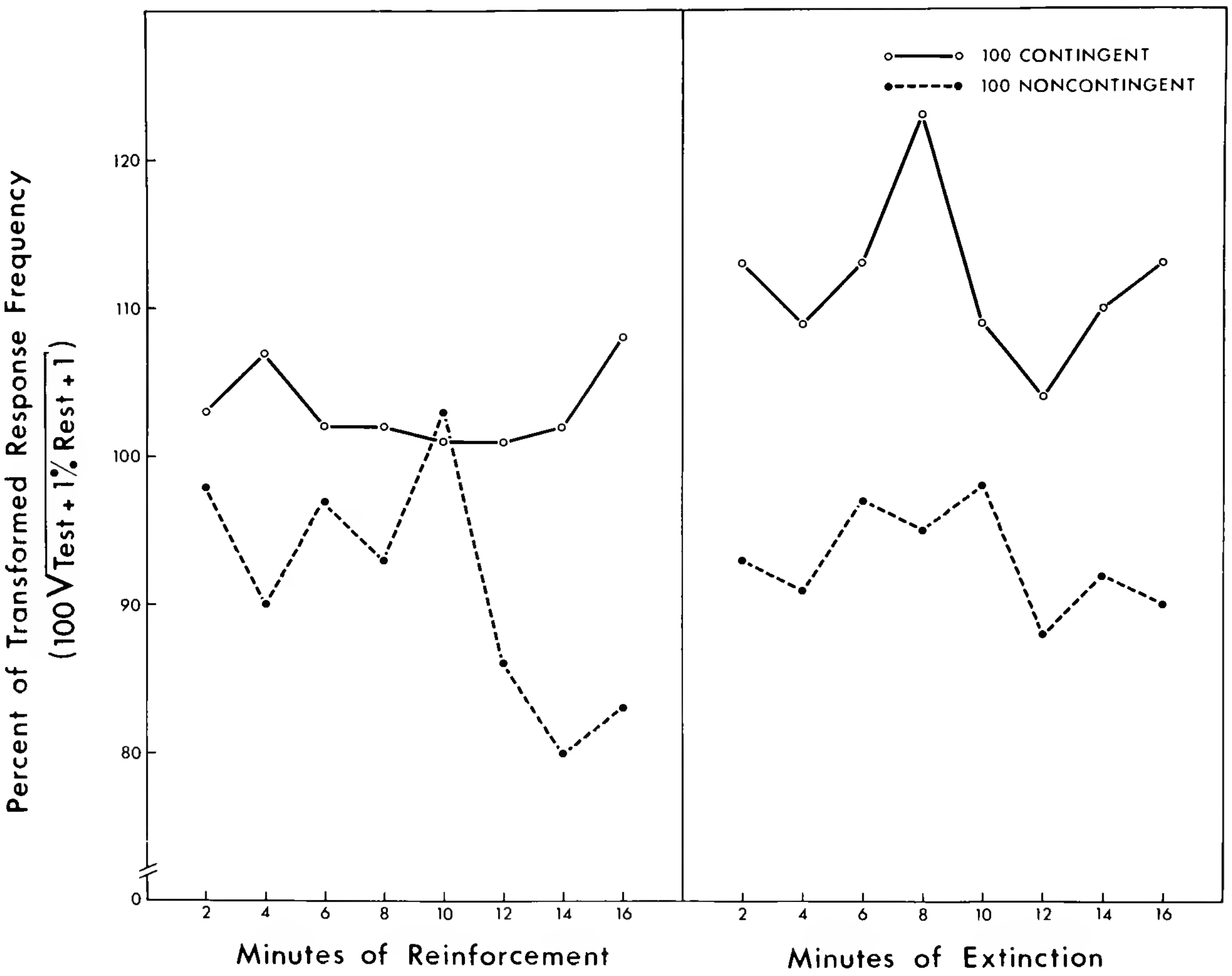

Fig. 5.--Percentage of transformed response frequencies during the 16 min. of acquisition and the 16 min. of extinction in 2-min. blocks for the <u>large</u> responses in the 100 percent groups.

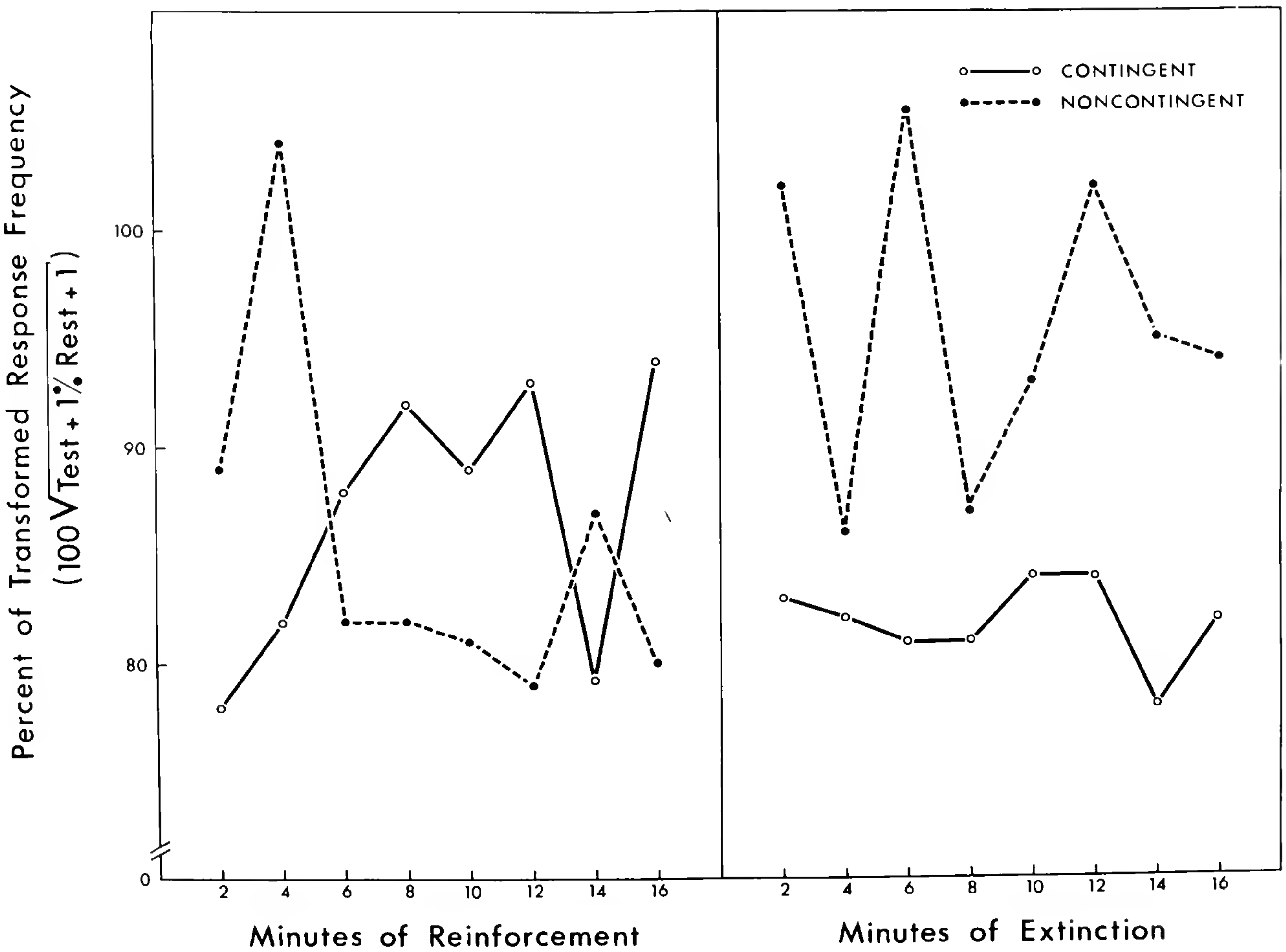

Fig. 6.--Percentage of transformed response frequencies during the 16 min. of reinforcement and the 16 min. of extinction in 2-min. blocks for the <u>small</u> responses of the 100 percent groups.

entire 16 min. of acquisition although no apparent trend is evident. During this same period the 100NC group responded consistently below the 100 percent base level and below the 100C group (except for one data point). An analysis of variance over the last 8 min. of acquisition was carried out on the transformed relative response frequencies grouped into 2-min. blocks and is summarized in Table 9. The analysis indicated that the obvious difference (for the last 8 min. of acquisition) between the two groups was significant ($F = 4.40$, $df = 1/28$, $p < .05$). In addition, the apparent increasing separation between the two groups over time from the 10th through the 16th min. was reflected in a significant Contingency X Minutes interaction ($F = 2.91$, $df = 3/84$, $p < .05$).

The second half of Fig. 5 shows the large response performance during the 16 min. of extinction. The figure shows that the 100C group initially increased responding, reaching a peak at 8 min., and then responded below this peak for the remaining 8 min. The 100C group responded <u>above</u> the 100 percent base level throughout the extinction period. The second half of Table 9 presents the analysis of variance for these data over the entire 16 min. of extinction. The analysis indicated that the difference between the Contingent and Noncontingent groups was significant ($F = 4.98$, $df = 1/28$, $p < .025$). The Contingency X Minutes interaction was not significant, indicating that the differences between the two groups did not change greatly during the extinction period.

Fig. 6 presents the curves of the mean transformed response frequencies of the 100C and 100NC groups for responses less than 1 percent of the base resistance. The figure shows the performance curves in

TABLE 9

SUMMARY OF ANALYSIS OF VARIANCE ON LARGE RESPONSES FOR THE LAST 8 MIN. OF ACQUISITION AND THE ENTIRE 16 MIN. OF EXTINCTION FOR THE CONTINGENT AND NONCONTINGENT GROUPS RECEIVING 100 PERCENT REINFORCEMENT (IN 2-MIN. BLOCKS)

	Acquisition			Extinction		
Source	df	MS	F	df	MS	F
(Between Ss)	(29)	1,758.77	-	(29)	4,653.45	-
Contingency	1	6,931.20	4.40*	1	20,375.95	4.98**
Error (b)	28	1,574.04		28	4,091.93	
(Within Ss)	(90)	401.46	-	(210)	391.53	-
Minutes	3	675.13	1.84	7	279.54	-
M x C	3	1,070.73	2.91*	7	319.16	1.04
Error (w)	84	367.78		196	305.56	

*$p < .05$.

**$p < .025$.

blocks of 2 min. for the 16 min. of acquisition and 16 min. of extinction. Since this class of response was tentatively identified as nonconditionable, the course of change for these responses was expected to be uncorrelated with reinforcement contingency. The first half of Fig. 6 indicates unsystematic changes. Analysis of variance of these data, however, resulted in a significant Contingency X Minutes interaction ($F = 2.97$, $df = 7/196$, $p < .01$). Examination of Fig. 6 indicates that this significant interaction effect was due to the large shifts in the magnitude of the differences between the two groups and the shifts in their relative positions. The extinction curves for this class of small responses are presented in the second half of Fig. 6. Immediately obvious from the figure is the apparent higher response rate and large fluctuations of the 100NC group. Throughout this period the 100NC group responded at a consistently higher rate than the 100C group, a result which is just the opposite of what would be expected were this response class being conditioned. Also apparent from Fig. 6 is the large increment in relative response frequency of the 100NC group from the last 2 min. of acquisition to the first 2 min. of extinction. An analysis of variance was carried out on the data for this 16-min. period of extinction. The apparent supreiority of the 100NC group in relation to the 100C group was statistically supported ($F = 4.77$, $df = 1/28$, $p < .05$).

Using the large and small responses, previously defined, as the dependent variables of 66C, 66NC, 33C, and 33NC groups were also further examined. Since no systematic effects were found, the data from these groups are not presented. The purpose of the presentation and analysis of the small and large responses will be considered in the next chapter.

CHAPTER IV

DISCUSSION

The purpose of the present study was to determine whether the course of conditioning and extinction of the unelicited GSR could be differentially influenced by different schedules of reinforcement. The results indicate that a differential effect was obtained. One group of Ss received a response-contingent, dim, white light as a positive reinforcement. This Contingent group was subdivided into three equal subgroups. Each subgroup received the reinforcer on a different fixed-ratio reinforcement schedule, viz., 100 percent, 66 2/3 percent, 33 1/3 percent. Yoked to each S in the Contingent group was an S who received the same number and pattern of reinforcements, but the delivery of the reinforcement was completely determined by the Contingent S. Thus, Ss in the Noncontingent groups received the reinforcer independent of their behavior.

Several facts led to the assumption that the dim white light used in the present study would act as a positive reinforcer. The Ss sat in an experimental room which was sound- and light-proof. Before actually beginning the delivery of the light, a 10-min. adaptation period was given during which time the S merely sat in the dark room. Thus, it would seem to follow that any mild changes in this sensorily deprived environment might serve as a reward. Several studies on animal Ss confirm this hypothesis. Barnes and Baron (1961), Barnes and Kish (1958),

and Kish (1955) found that when mice were confined to a dark chamber significant increases in number of bar contacts were obtained when light onset was made contingent upon bar contacts. Fox (Solomon, 1961) was able to train monkeys to press a lever to turn on a light when they were kept in a dark chamber. When the monkeys were next deprived of light for a period of hours and then given access to the bar, a large and significant increase in responding occurred. These studies help define the brief light used in the present study as a positive reinforcer. Perhaps even more important for the definition of the light as a positive reinforcer are the investigations by Fowler and Kimmel (1962) and Kimmel and Kimmel (1963). Both of these studies were designed to condition the GSR instrumentally with a brief flash of dim white light as the positive reinforcer. Both studies reported positive results.

Hypothesis 1

The first hypothesis of concern in the present study stated that the Contingent groups would emit a greater number of responses during acquisition and extinction than the Noncontingent groups. Analysis of the data indicated the confirmation of this hypothesis for the acquisition period. The over-all average relative response frequency for the Contingent groups was 95.8 percent while for the Noncontingent groups it was 88.3 percent. This superiority of the Contingent groups was statistically significant ($F = 6.23$, $df = 1/84$, $p < .025$). The previous studies (Fowler and Kimmel, 1962; and Kimmel and Kimmel, 1963) on conditioning of the unelicited GSR also reported such differences during the acquisition period. Thus, the present result confirms the previous

findings and is in agreement with them. However, an important procedural change introduced in the present study should be emphasized at this point. The earlier studies using this technique delivered noncontingent reinforcement only at times when the S was not making a response. That restriction precluded the delivery of the reinforcer fortuitously when a response was being emitted. However, in the present study an S in the Noncontingent group could receive a reinforcement at any time, whenever his Contingent mate received one. It had been anticipated that this would result in smaller absolute differences between the Contingent and Noncontingent conditions. This, in fact, did occur. To determine the extent to which a Noncontingent S was reinforced for emitting a GSR, the number of reinforcing lights (a response was considered reinforced if the light occurred contiguously with the response or within 1 sec. after) was divided by the total number of lights received by an S. This score was then expressed as a percentage for each S. The means and standard deviations of the percentages of the reinforcing lights for the three Noncontingent groups were: 100NC, Mean = 18.93 percent, SD = 10.25 percent; 66NC, Mean = 20.07 percent, SD = 9.26 percent; 33NC, Mean = 22.33 percent, SD = 12.05 percent. When the present study is compared to the Kimmel and Kimmel (1963) study, the absolute effects were smaller. However, despite this procedural change, reliable differences were obtained in the present study.

During the extinction the over-all difference between Contingent and Noncontingent groups only partially supports the hypothesis. The mean of the Contingent group was 101 percent while that of the Noncontingent group was 95 percent. However, this difference was not

statistically significant. Analysis of the data of the Noncontingent groups during the first 8 min. of extinction showed that the 66NC and 33NC groups gradually increased in response frequency until, at the end of 8 min., their relative percent response was approximately equal to their base rates as determined during the last 4 min. of adaptation. These two groups showed extinction curves comparable to the extinction curve obtained in the Kimmel and Kimmel (1963) study for a 100NC group, although the extinction was faster in the present two groups. This more rapid extinction was probably due to the difference in the procedure associated with the delivery of the noncontingent reinforcement (described above), and to the fact that the Ss in the 66NC and 33NC groups of the present study received considerably fewer lights[13] than the Ss of the 100NC group of the other study. The main reason the hypothesis under consideration was only partially supported was due to the relative performances of the 100C and 100NC groups. Of considerable interest was the fact that the 100NC group demonstrated what can best be termed "Immediate extinction. This group shifted from having the lowest relative response rate in the Noncontingent groups during the last 2 min. of acquisition to having the highest relative response rate during the first 2 min. of extinction. Furthermore, the 100NC group was actually responding higher than the 100C group during the first 2 min. of extinction. This finding was not in agreement with either the Fowler and Kimmel (1962) or Kimmel and Kimmel (1963) study. In the Fowler and

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[13]The mean number of lights received by the Ss in each Noncontingent group was: group 100NC, 67.73; group 66NC, 47.53; group 33NC, 22.40.

Kimmel study the difference between the two groups (100C and 100NC) was found to be statistically significant in extinction during the first minute. In the Kimmel and Kimmel study large and significant differences occurred during the <u>entire</u> 10-min. period of extinction for the two groups (100C and 100NC) comprising that study. The contrast between these and the present results cannot be easily dismissed and will be dealt with below. It must be concluded, nonetheless, that the noncontingent reinforcement procedure used in the present study was not as effective in maintaining the difference between Contingent and Noncontingent groups during extinction as was the procedure of delivering the reinforcement to Noncontingent <u>S</u>s only when an <u>S</u> was <u>not</u> making a response.

<u>Hypothesis 2</u>

The second hypothesis tested in the present study was concerned with the influence of the three schedules of partial reinforcement upon the performance of the Contingent groups. The prediction specifically stated that the highest rate of responding would occur in the 33C group both during acquisition and extinction. The next highest level of responding was expected to occur in group 66C followed by group 100C. It was expected that this ranked relationship would hold during acquisition and extinction.

The results indicated that during both acquisition and extinction the highest rate of responding was given by group 33C followed by group 66C and then group 100C, thus confirming the hypothesis. It was noted that the maximum difference between the three Contingent groups occurred during the <u>first</u> 2-min. blocks of acquisition and extinction.

The over-all differences among the Contingent groups were not statistically significant, but analysis of the first 2-min. block of acquisition showed the 33C group to be significantly more responsive than the 66C group ($\underline{t}$ = 1.93, $p < .05$) and also greater than the 100C group (t = 2.68, $p < .025$). A trend analysis indicated that the three groups converged during acquisition. Thus, only during the early part of training did the higher ratio of responses required for reinforcement result in higher response rates.

In the Kimmel and Kimmel study (1963) it was noted that the strong conditioning effect apparent during the early part of training decreased as the acquisition period continued. The present results partially confirmed their findings. One possible explanation of this effect may be that postulated by Kimmel (1962), namely, that the "need" for the light gets satiated, or it may be that some kind of inhibition grows as a function of the number of reinforcements. A high initial response rate followed by decreased responding has also been found in rats, when light served as the reinforcer (Barnes and Baron, 1961); and, in the present study, in group 33C. It will be of interest to determine in future research if the obtained acquisition curves for conditioning of the unelicited GSR are a function of the reinforcer used or the response system itself.

During extinction the ranked means of the three Contingent groups were in the hypothesized order, but statistical analysis failed to support the apparent differences. Of some interest was the effect of partial reinforcement on the three groups' performance during the first two 2-min. blocks. Only during this interval could the effect easily be

observed. By the 8th min. of extinction, the groups were responding almost identically although there was some divergence during the later minutes. During the last 2-min. block of acquisition the differences among these groups had almost disappeared, yet, with the removal of the reinforcer, large differences reappeared during the first few minutes of extinction. The behavior of the groups seemed to indicate that maximal performance differences occur as a function of the schedule of reinforcement <u>and</u> of change in conditions. In another study on operant conditioning of the GSR, Kimmel and Hill (1960) used several different response-contingent reinforcers and obtained maximum effects after reinforcement was terminated. However, this large change in responding at the beginning of extinction was not found in the other two operant GSR conditioning studies (Fowler and Kimmel, 1962; Kimmel and Kimmel, 1963). No explanation of this discrepancy between studies is apparent.

The present results support the hypothesis that partial reinforcement of the unelicited GSR results in higher rates of responding during acquisition and greater resistance to extinction than does continuous reinforcement although the effect was apparent only during the initial periods of each condition.

<u>Hypothesis 3</u>

The behavior of the Noncontingent groups, in addition to their control use, was of interest <u>per se</u>. Fowler and Kimmel (1962) found that their Noncontingent group emitted fewer and fewer responses during the acquisition period and responded significantly less than the Contingent group during the 1st min. of extinction. Kimmel and Kimmel

(1963) obtained approximately the same result during acquisition for their Noncontingent group. In this latter study, the extinction period was prolonged from 4 to 10 min. and it was found that the Noncontingent group showed a gradual increase in the number of responses emitted during extinction.

This trend of increased responding continued until, at the end of the 10-min. period, the frequency of responses was almost as great as the initial base level. The interpretation given by Kimmel (1962) for this effect was that the Ss in the Noncontingent group must have learned not to respond during the acquisition period (the noncontingent light was delivered only when the Ss were not responding). During extinction the Ss stopped not responding and, thus, their response frequency curve gradually rose. In the present study three different groups of Ss were run under the modified noncontingent procedure as previously noted (e.g., p. 47). Each of the three groups received a different number of noncontingent reinforcements which accompanied the reinforcements delivered to the Contingent Ss (cf. p. 48).

The third hypothesis was formulated under the two assumptions that the delivery of the noncontingent reinforcement would result in decreased responding and that the amount of decrease would bear a direct relationship to the number of reinforcements delivered, as it was determined that the Noncontingent Ss were actually being trained on a modified variable-interval schedule of reinforcement with the 100NC group receiving the shortest interval. Specifically, the hypothesis stated that the 100NC group would give the least responses, followed by the 66NC group, and then the 33NC group. Examination of the performance

curves during the last 8 min. of the acquisition period confirms the hypothesis. Comparison of these performance curves with the results of the Kimmel and Kimmel study (1963) indicates that the terminal response frequencies were very similar for the 100NC groups. The major differences between the two studies with respect to these two groups was that the rate of decrease in responding in the Kimmel and Kimmel study (1963) was more rapid than in the present study. This result would be expected due to the methodological differences of noncontingent reinforcement. During extinction it was expected that the relative response frequencies of the three Noncontingent groups would gradually increase. The results confirmed this expectation for only the 66NC and 33NC groups. The response frequency curves for these two groups may be compared to the extinction curve of the Noncontingent group of the Kimmel and Kimmel (1963) study. Extinction occurred more rapidly in the present study, however. The results indicated that extinction occurred during the first 8 min. of the extinction period while, in the earlier study, a 10-min. period was required. The major difference with respect to these groups in the two studies is that, in the present study, although giving similar shaped extinction curves, the Noncontingent Ss responded at a higher level throughout the acquisition and the extinction period.

The behavior of the 100NC group of the present study was certainly different from what was expected. It should be noted, however, that the over-all relative response frequency of this group (for the entire 16 min.) was below all other groups, as was predicted. There remains to be explained, however, the behavior of this group during the first part of extinction. It would seem that an "expectancy" or

"discrimination" hypothesis could be used to account for the "immediate" extinction apparently given. However, this hypothesis would fail to handle the results of the earlier studies. Examination of the data for the individual Ss indicates that 11 of the 15 Ss in this group increased in response frequency during the first 2 min. of extinction when compared with the last 2 min. of acquisition. This fact indicates that the apparent increase was not an artifact resulting from only one to two Ss who might have shown large response shifts. Two possibilities remaining are that the shift was a chance occurrence or that the increased responding was related to the high frequency of reinforcement coupled with the particular method of delivery of noncontingent reinforcement used in the present study.

Hypothesis 4

Fowler and Kimmel (1962) and Kimmel and Kimmel (1963) had demonstrated that the removal of the reinforcing stimulus resulted in a decrease in the magnitude of the differences between the Contingent and Noncontingent groups over time. These decreasing differences were interpreted as extinction effects and were clearly shown in the Kimmel and Kimmel (1963) study. In that study a significant Contingency x Minutes interaction was obtained in the extinction data. Their extinction period was marked by a gradual decrease in responding in the 100C group and a gradual increase in responding in the 100NC group. The fourth hypothesis of the present study was, in effect, a prediction based upon these previous findings. It follows from the hypothesis that the differences

obtained among the six experimental groups would diminish or disappear during the extinction period.

The extinction period was extended to 16 min. in the present study to allow for the possibility of greater resistance to extinction in the partial reinforcement groups. The results during extinction were presented in Figs. 2, 3, and 4. Inspection of these figures definitely indicates a disappearance of group differences, and thereby, confirmation of the hypothesis. Closer inspection of the data during the extinction period reveals several interesting trends. First, the statistical analysis did not show a significant Contingency effect or a significant Contingency x Minutes interaction. This fact alone could mean that extinction occurred immediately upon termination of the reinforcement period. The performance curves presented in Figs. 3 and 4 support the contention of immediate extinction only for group 100NC. On the other hand, groups 66C and 66NC definitely showed a more gradual extinction. For the first 4 min. group 66C was responding above group 66NC. During the next 4 min. group 66C dropped sharply and then rose again to a point above the 100 percent base line. This fluctuation continued for the remaining 8 min. of extinction. The behavior of group 66NC during the first 8 min. of the extinction period nicely illustrated the expected gradual extinction curves. Beginning with the first 2-min. block, this group increased in response rate in an almost linear fashion until the 8th min. Comparison of groups 33C and 33NC during the first 8 min. of extinction also showed decreasing responding for the 33C group and increasing responding for the 33NC group; both groups reaching almost the same response level at the end of 8 min. These apparent differences

during the first 8 min. of extinction were accompanied by a significant Contingency x Ratio x Minutes interaction ($F = 2.37$, $df = 6/252$, $p < .05$), a significant Contingency x Ratio interaction in the linear component of the trends across extinction ($F = 3.41$, $df = 2/84$, $p < .05$), and a significant Contingency x Minutes interaction ($F = 3.05$, $df = 3/168$, $p < .05$) for groups 33C, 33NC, 66C, and 66NC. On the basis of the data and the statistical analyses, it may be concluded that significant extinction effects were obtained during the first 8 min. of extinction in all groups except the 100C and 100NC. These results agree to some extent with the previous findings.

The explanation for the equivocal results obtained in groups 100C and 100NC and also for the fluctuations occurring in some of the other groups during the last 8 min. of extinction is not clear. Between Ss variances indicated large intersubject differences. Examination of the data of individual Ss indicated that many of them showed wide ranges of responding.

Incomplete adaptation and responding below the 100 percent base rate

The Fowler and Kimmel study (1962) had allowed only 4 min. of adaptation and the records indicated continuously falling curves for both Contingent and Noncontingent groups during the reinforcement period. The Kimmel and Kimmel study (1963) allowed 10 min. of adaptation prior to the beginning of the reinforcement period. This was done to allow the Ss to adapt more completely to the experimental chamber and for their response rates to stabilize. Since the mean performance curve of the Contingent group in that study was above the 100 percent base level

during acquisition, they concluded that their extended adaptation period had adequately handled the problem. However, upon examination of the Kimmel (1962) data for relative response frequencies of each S, the present investigator found that during the first minute of acquisition only nine Ss of the 15 Ss actually were responding above their own 100 percent base rates, although the mean of the relative response frequencies during the 1st min. was 126 percent! By the 2nd min. of acquisition only seven Ss of the 15 Ss were responding above the 100 percent base level. Examination of the remaining min. of acquisition for each S indicated that only about one-half the Ss were responding above the 100 percent base. The extention of the adaptation period, then, only partially handled the problem of adaptation when viewed with regard to the individual Ss.

One of the differences between the present study and the earlier studies is that a new laboratory facility was used. The experimental room was smaller, more sourdproof, and these characteristics may have stressed the Ss. Although a full 10 min. of adaptation was given, and, although the group response curves showed an adaptation effect, it was possible that adaptation did not fully occur.

Hypothesis 5

The 0 percent control group of the present study was included to determine the frequency output of the unelicited GSR for a time period comparable to the experimental conditions. The mean percent transformed response frequencies of this group were presented in Table 8. The data in Table 8 indicate partial confirmation of the hypothesis, in that

after an initial decrease in responding (adaptation) the mean response frequency tended to stabilize. However, the mean response frequency for the group showed a slight increase during min. 11-20. This increased responding after about 10 min. may be an indication of stress in the situation (Malmo, 1959). If the Ss were stressed by the lack of stimulation, then the effect of the light stimulus may have functioned as more than a reinforcer in the Contingent and Noncontingent groups. The light may also have given the S something to attend to in his otherwise sensorily impoverished conditions and may have resulted in decreased responding. This could account for the higher rate of responding of the 0 percent control group in comparison to the Contingent groups during acquisition. It is more likely that the major variable in the present experiment which was responsible for the over-all reduced responding of the Contingent groups was the reinforcement of responses that were so small that either (a) the S could not discriminate these small responses from no responses at all, or (b) they could not be conditioned by instrumental means (assuming that "small" and "large" unelicited GSRs are due to different processes). Both of these hypotheses are developed below.

Decreased responding and the small responses

It was previously noted that the sensitivity of the present recording equipment was greater than that of the equipment used in the prior studies. In addition, the Es in the previous studies (Fowler and Kimmel, 1962; Kimmel and Hill, 1960; and Kimmel and Kimmel, 1963) monitored the GSR record visually and delivered the reinforcement when the

particular response criterion had been met. In the present study the Ss' GSR was passed through a differential amplifier which automatically delivered the reinforcer when a "criterion" response occurred. This device was much more sensitive to the very small unelicited GSRs (i.e., 10-25 ohms) than was possible in the earlier studies. Assuming, thus, that the procedure in the present study resulted in the delivery of reinforcements for smaller responses, the following additional assumption becomes necessary to understand the effects this had. Kimmel (1962) assumed that one of the conditions necessary for the successful operant conditioning of an autonomic response is proprioceptive feedback from that response. In other words, the response must produce stimuli of sufficient magnitude to be above the physiological noise level of the S. The mechanism for feedback from autonomic activity is provided by afferent (sensory) nerves in the structures controlled by the autonomic system (Young, 1961). These afferent impulses go to the reticular formation and hypothalmic centers and influence cortical activity. This is the presumed feedback system. With this system, and given the large number of small responses reinforced, we have a possible explanation for the suppressed response rates. The very small responses emitted by an S were detected and reinforced by the apparatus in addition to the large responses. The difference between the size of a very small response and a very large response could be a factor of about 200 in some cases. If we assume that these very small responses provided no or little feedback then it follows that reinforcements were being delivered when no "effective" responses were being emitted. In this case we could expect the response rate to decrease, since this condition is very similar to

noncontingent reinforcement. The data show that delivery of a reinforcement when no response is occurring definitely results in decreased responding.

An interesting hypothesis regarding the nature of these small responses can be developed. Lacey and Lacey (1958) report that spontaneous activity of living tissue results in discharges, no matter how carefully controlled the stimulus conditions may be. In addition, they indicate that this activity is stable over time. They have postulated that the GSR shows this type of spontaneous activity and that the locus of its initiation is in the ". . . physiochemical processes at the level of _localized_ cell aggregates." (p. 163, italics not in original) If these responses _are_ stable over time, do not show an adaptation effect, and are a function _solely_ of local peripheral activity, it is highly likely that they are not influenced by reinforcement.

Nature of the large response

The "large" unelicited GSR is probably cortically initiated and innervated via the autonomic nervous system. Fulton (1943) reported that autonomic and somatic nerves are interdependent in that there is extensive overlapping between the two in the cortex. It may be that only these cortically initiated GSRs adapt over time and are operantly conditionable. The problem would be to find a means by which these two types of responses can be differentiated.

Conditioning the small and large responses

In the present study a dichotomy was made between large and small responses by counting as a small response all pen deflections less

than 1 percent of an S's base resistance, and as a large response all those responses greater than or equal to 1 percent of the base resistance. Figs. 5 and 6 presented these data for groups 100C and 100NC (chosen for illustrative purposes) during acquisition and extinction. The performance curves support the reasoning developed above. Conditioning appeared to occur in the large responses, but not in the small. The results are contaminated in the present case, however, in that all responses (large and small) were reinforced.

Adaptation of small and large responses

Further support for the stability of the small responses over time and the adaptation of the large responses would obtain if it could be shown that the frequency of the former response remained steady during the adaptation period while the larger responses showed an adaptation effect. To examine this possibility the adaptation data for the six groups of the main experiment were divided into small and large responses as explained above. These relative response frequency curves are presented in Fig. 7 in 2-min. blocks for the 10-min. adaptation period. The small responses in the left half of the figure do not show an adaptation effect, as is indicated by their fluctuating around their 100 percent base level. The right half of the figure shows the curves for the large responses. Immediately obvious is the decreasing relative response frequencies over time. This decrease is interpreted to mean that adaption occurred for the large type of response. A test of the significance of the linear component of the trend of these data indicated a large significant negative slope ($F = 20.80$, $df = 1/84$, $p < .001$) for the large responses.

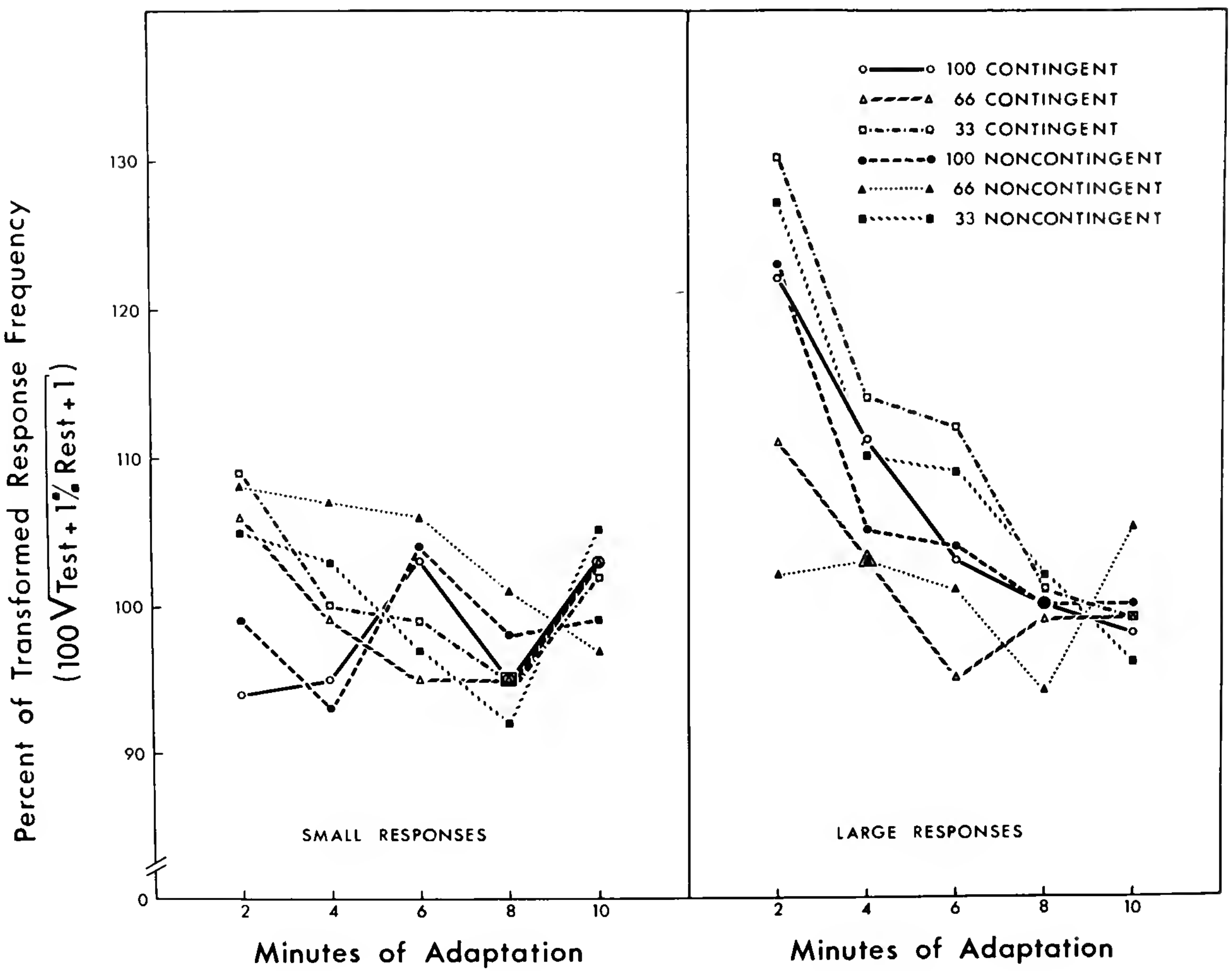

Fig. 7.--Percentage of transformed response frequencies during the 10-min. adaptation period in 2-min. blocks for the <u>small</u> and <u>large</u> responses of the Contingent and Noncontingent groups.

The hypothesis regarding two types of unelicited GSRs finds support in these data. This finding can account for the relatively depressed response rates observed in the present study. In addition, the possibility now exists for obtaining a very strong conditioning effect, in future studies, as well as achieving greater control over the unelicited GSR. This task would require differential reinforcement of responses distinguished by a magnitude criterion. It would be necessary to reinforce several different magnitudes to obtain a better understanding of the phenomenon.

Conclusion

The results of the present study indicated that the unelicited GSR can be differentially influenced by Contingency and Schedules of reinforcement. The effect of Contingency of reinforcement shows that the unelicited GSR can be made instrumental, and, thereby operate upon the environment. Formerly, this fact was thought to be true for somatically mediated responses only. In addition to the Contingency variable, however, the influence of other variables can be demonstrated with the more conventional instrumental responses. For example, magnitude, delay, and type of reinforcement all influence the acquisition and extinction of instrumentally conditioned somatic responses. Another important variable determining performance is the schedule of reinforcement. Showing that schedules of reinforcement have a similar effect upon instrumentally conditioned autonomic responses allows for the possibility of an underlying mechanism and set of laws which apply to both somatic and autonomic response systems. The present study has demonstrated that

fixed-ratio schedules of reinforcement do differentially influence the unelicited GSR in a fashion somewhat similar to their influence on somatically mediated responses.

With these findings, in conjunction with the results of Fowler and Kimmel (1962) and Kimmel and Kimmel (1963), the hypothesis regarding the nonconditionability of autonomic responses by instrumental means is further weakened.

Operant conditioning of autonomic responses now requires additional research to determine the particular nature of the response which can be conditioned, the influence of other types of schedules of reinforcement upon the response, and the study of additional parameters of which instrumental somatically mediated responses have been shown to be a function.

CHAPTER V

SUMMARY

The purpose of the present study was to determine the influence of partial reinforcement upon acquisition and extinction of the unelicited GSR. Ninety college students were divided into two major groups (Contingent [C] and Noncontingent [NC]). The Contingent group was divided further into three subgroups each of which received a different schedule of partial reinforcement on a fixed-ratio (100 percent, 66 2/3 percent, and 33 1/2 percent). All Ss were run in a light-proof, sound-proof experimental chamber. Each Noncontingent S was paired to a Contingent S of the same sex and was run in another experimental chamber at the same time. The delivery of the reinforcer (a dim white light), to both Ss, occurred whenever the Contingent S had emitted the required number of GSRs.

All Ss received a 10-min. period of adaptation, the last 4 min. of which provided a base measure of resting response. After the 10-min. adaptation period was completed, a 16-min. period of reinforcement was given, during which the Contingent groups received the light following the emission of a GSR (the number of emitted GSRs required to receive a light was determined by the schedule of reinforcement). Finally, there followed a 16-min. period of extinction during which no stimuli were given.

The dependent variable was the number of responses emitted per 2-min. block expressed as a percentage of the number of responses emitted during the base resting period (all frequencies were first transformed to $\sqrt{x+1}$).

During reinforcement the over-all rate of responding was greater in the Contingent group than in the Noncontingent group ($p < .025$). Among the Contingent groups the effect of partial reinforcement was maximal during the initial minutes of reinforcement. A significant convergence of these Contingent groups was obtained over the 16 min. of reinforcement ($p < .05$). The extinction period was marked by the convergence of the Contingent and the Noncontingent groups. It appeared that extinction was completed by the first 8 min. (the Contingent groups decreased responding while the Noncontingent groups increased). However, the differences between groups 100C and 100NC fluctuated widely. During extinction the effect of partial reinforcement upon the Contingent groups was most obvious at the beginning of the extinction period. The highest responding occurred in group 33C followed by group 66C and then group 100C. These differences had almost vanished at the end of 8 min. of extinction, except that group 33C continued to respond above all other groups throughout the 16 min. of extinction.

A 0 percent control group (15 Ss) was also run. These Ss merely sat in the dark soundproofed experimental chamber with no stimulation for 42 min. This group showed an initial adaptation effect, followed by fairly steady (but unexpectedly high level) responding during the last 32 min.

The low response rates of the Contingent groups, compared to the 0 percent control and to a similar group in the Kimmel and Kimmel (1963) study, were interpreted as due to reinforcement of very small GSRs which were not reinforced in the previous study. An hypothesis was developed regarding the nature of the small and large GSRs and their conditionability by instrumental methods. Finally, further research on this problem was proposed.

It was concluded that (a) the effect of partial reinforcement was greatest at the beginning of acquisition and at the beginning of extinction; (b) the present study confirmed and agreed with the previous studies (Fowler and Kimmel, 1962; and Kimmel and Kimmel, 1963) which showed that Contingent reinforcement resulted in higher response rates than Noncontingent reinforcement; and (c) the hypothesis stating that autonomic responses are not conditionable by instrumental means (Kimble, 1961) was weakened further.

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APPENDICES

APPENDIX A

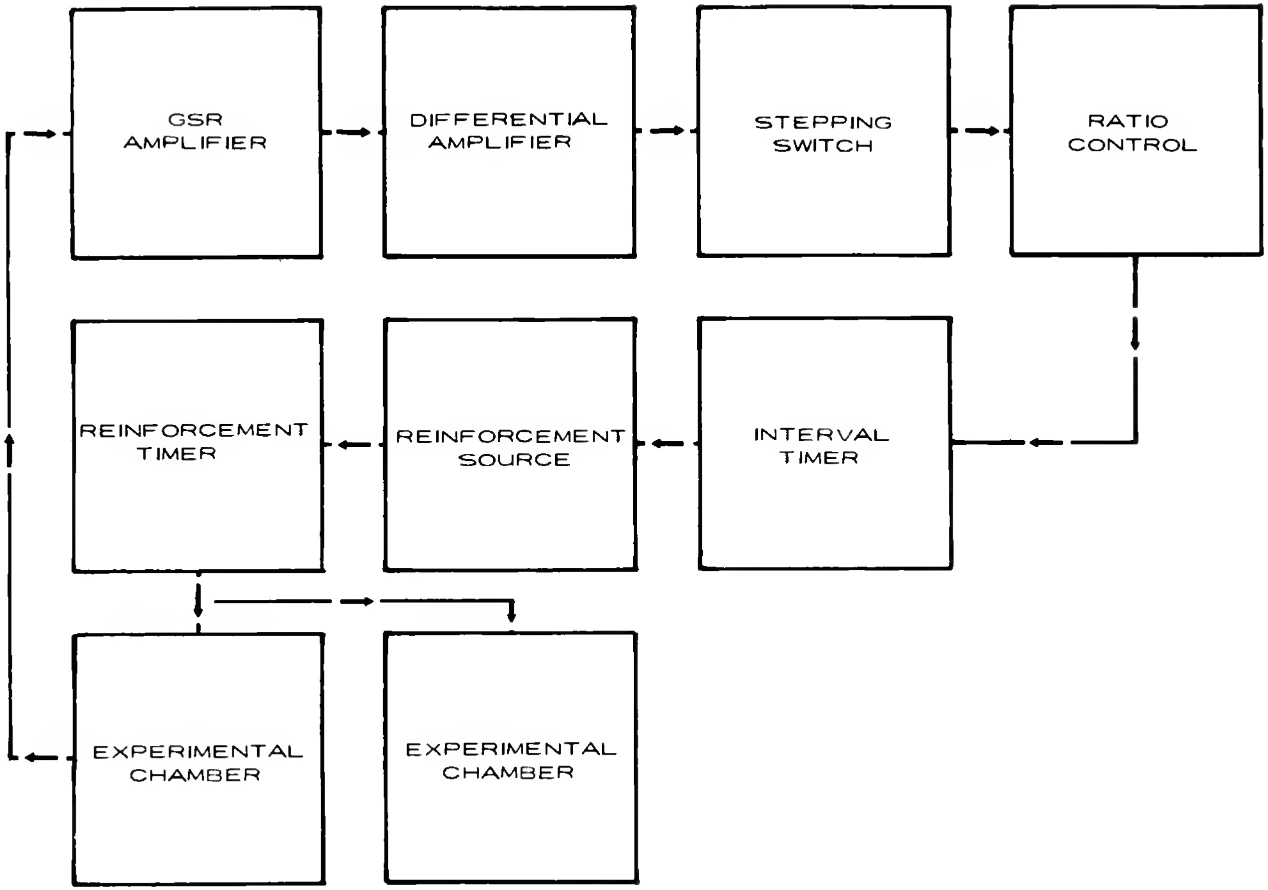
INSTRUCTIONS

Your task in this experiment is merely to relax, remain as motionless as possible, and pay attention to what happens. Since we will be recording your galvanic skin response with very sensitive equipment, it is absolutely imperative that you avoid abrupt movements, deep or uneven breathing, etc.; because any activity of this sort will produce errors in our data. We would like for you to get as comfortable as possible now, before we begin recording, so that you will be able to remain still when we start. If it becomes necessary to move (for example to scratch your nose), please do so with your free hand with as little abruptness as possible. Don't cross or uncross your legs or move about in the chair--just relax.

You will find that the more relaxed you can get, the easier it will be to remain still. Yet, it is necessary that you remain alert in the sense of paying attention to what may happen. That is, keep your ears, eyes, etc. open. This is also an absolute necessity. Do not give in to any tendency to become drowsy; do not close your eyes.

Do you have any question?

APPENDIX B



REINFORCEMENT CONTROL SYSTEM

Fig. 8.--Diagram of the system controlling reinforcement.

APPENDIX C

TABLE 10

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 100 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	5	2	0	7	4
2	6	12	9	12	16
3	12	8	6	4	[illegible]
4	2	3	2	3	6
5	1	2	7	6	14
6	17	17	15	18	12
7	11	15	8	8	10
8	*	11	9	11	13
9	15	12	17	7	8
10	15	14	17	11	13
11	9	8	14	16	17
12	5	5	6	4	1
13	20	16	20	15	18
14	26	19	20	16	20
15	17	14	18	14	18

*The recording apparatus was not started until the third minute of adaptation.

TABLE 11

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 100 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	2	3	3	4	4	4	4	10
2	8	9	10	7	9	7	10	9
3	5	8	6	5	1	2	2	3
4	5	2	4	2	3	3	2	4
5	3	7	8	11	11	8	4	9
6	9	11	8	10	7	9	8	10
7	11	2	7	8	5	8	8	4
8	9	11	13	14	14	14	15	11
9	10	9	8	7	11	11	8	10
10	8	15	12	11	10	13	8	13
11	4	4	5	9	11	10	14	14
12	4	4	5	3	2	4	5	2
13	7	15	17	15	11	19	12	14
14	17	17	12	13	13	10	8	14
15	8	10	11	13	13	13	12	11

TABLE 12

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 100 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	2	4	7	7	4	7	10	4
2	12	13	15	13	12	8	8	8
3	1	0	2	1	2	0	0	0
4	5	3	4	5	5	4	3	7
5	11	10	10	16	11	10	11	11
6	11	12	11	11	14	11	13	11
7	6	7	5	8	8	8	6	7
8	14	10	10	13	12	12	4	10
9	9	8	6	5	8	7	9	11
10	16	12	13	13	11	11	8	9
11	11	12	15	14	16	10	11	12
12	2	5	4	7	4	6	15	4
13	23	16	17	17	13	11	15	18
14	16	19	17	16	12	11	13	10
15	13	16	11	15	14	15	19	14

APPENDIX D

TABLE 13

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 66 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	21	10	8	7	18
2	1	0	1	3	2
3	9	9	6	6	7
4	13	17	20	18	15
5	8	9	8	9	11
6	7	7	2	6	5
7	5	4	3	3	5
8	9	12	15	13	18
9	25	19	18	18	19
10	13	5	7	5	6
11	2	9	1	8	11
12	17	14	14	11	13
13	18	11	16	15	12
14	17	12	12	11	11
15	17	10	12	9	15

TABLE 14

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 66 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	13	7	4	5	3	11	16	16
2	3	4	3	4	6	8	5	5
3	8	7	6	9	4	7	7	5
4	16	16	12	12	19	18	13	17
5	10	13	6	6	7	6	5	4
6	3	5	3	7	5	6	9	8
7	3	5	5	4	7	5	4	7
8	9	10	13	12	11	11	12	11
9	12	13	15	19	17	14	17	15
10	7	4	8	8	8	5	9	5
11	6	5	3	4	6	5	6	2
12	9	8	9	10	12	12	13	15
13	13	14	13	15	13	15	15	11
14	7	10	10	11	10	8	11	6
15	9	12	12	10	10	12	8	5

TABLE 15

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 66 PERCENT CONTINGENT SUBJECTS

S Numbers	2	4	6	8	10	12	14	16
1	16	10	4	7	11	12	15	10
2	8	7	9	3	1	6	5	8
3	6	4	8	7	7	3	6	3
4	24	23	24	29	18	17	27	19
5	2	4	5	5	5	3	8	2
6	11	10	5	10	12	7	14	7
7	3	5	1	9	5	9	6	6
8	14	12	10	11	14	16	5	12
9	23	22	17	21	21	22	28	14
10	4	7	4	6	4	6	6	6
11	6	5	3	4	5	5	4	5
12	15	11	14	18	14	17	18	13
13	15	17	12	15	14	18	24	10
14	8	12	9	7	11	7	12	5
15	12	11	14	15	6	13	10	4

APPENDIX E

TABLE 16

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 33 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	2	2	5	2	3
2	9	3	4	1	3
3	9	13	10	15	8
4	11	9	7	8	9
5	8	6	3	6	10
6	25	20	19	9	12
7	28	19	15	15	16
8	16	10	7	8	7
9	12	15	13	12	13
10	21	8	14	11	11
11	7	4	4	1	6
12	10	12	13	7	10
13	20	19	21	14	6
14	18	19	24	22	16
15	5	4	3	4	4

TABLE 17

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 33 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	4	5	1	3	9	3	5	4
2	1	1	5	4	2	1	0	2
3	13	8	5	8	14	6	10	9
4	11	6	8	8	4	4	5	8
5	9	8	12	10	13	15	15	12
6	14	10	7	7	5	6	9	5
7	12	15	11	10	10	8	9	12
8	13	4	7	7	10	6	6	5
9	15	16	12	10	11	9	8	10
10	16	16	8	9	7	10	11	3
11	7	5	7	5	6	8	8	8
12	4	5	8	7	5	9	7	9
13	9	9	12	14	13	18	13	15
14	18	12	18	14	16	12	9	11
15	5	4	4	3	6	4	6	4

TABLE 18

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 33 PERCENT CONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	10	14	10	10	14	7	4	9
2	6	2	4	2	1	2	7	8
3	17	10	11	12	14	12	13	11
4	10	6	8	6	5	1	8	8
5	13	10	11	10	13	11	12	11
6	12	6	8	11	6	15	10	10
7	9	7	6	3	7	5	7	7
8	3	9	6	9	10	12	6	9
9	12	14	10	15	10	13	7	9
10	6	6	10	11	14	16	12	5
11	13	11	8	2	2	4	5	4
12	7	12	15	11	14	10	9	11
13	14	14	9	12	13	12	13	14
14	15	12	9	14	17	10	12	14
15	5	5	5	5	7	9	7	3

APPENDIX F

TABLE 19

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 100 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	14	8	9	5	6
2	10	13	10	11	11
3	4	1	2	1	0
4	21	14	15	13	14
5	9	6	10	9	7
6	3	5	7	11	9
7	11	6	7	4	5
8	*	20	24	23	25
9	9	7	20	4	7
10	20	17	20	17	21
11	12	13	11	15	7
12	4	3	2	3	3
13	10	11	14	12	12
14	20	22	24	23	26
15	14	12	12	14	14

*The recording apparatus was not started until the third minute of adaptation.

TABLE 20

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 100 PERCENT NONCONTINGENT SUBJECTS

S Numbers	2	4	6	8	10	12	14	16
1	9	5	7	3	4	2	4	2
2	5	6	4	7	8	7	4	6
3	4	6	3	0	0	2	2	3
4	15	13	12	9	12	11	10	9
5	2	6	3	9	7	9	5	5
6	4	5	4	7	4	2	2	1
7	4	2	2	5	4	3	3	5
8	16	13	18	10	15	10	12	14
9	5	4	2	4	2	0	1	0
10	14	12	18	12	14	14	13	12
11	12	6	2	4	12	3	4	4
12	3	5	3	0	5	1	1	1
13	4	9	8	10	6	10	7	4
14	15	16	14	13	21	25	20	19
15	7	11	10	14	9	9	10	9

TABLE 21

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 100 PERCENT NONCONTINGENT SUBJECTS

S Numbers	2	4	6	8	10	12	14	16
1	1	5	8	7	5	1	2	1
2	9	3	13	7	8	8	7	4
3	3	1	1	0	1	3	2	1
4	5	3	13	3	6	8	5	7
5	11	10	15	12	11	9	9	11
6	8	6	8	6	8	11	17	13
7	5	4	8	5	15	4	6	5
8	18	15	24	22	15	18	20	14
9	3	3	1	2	1	1	3	0
10	18	21	10	14	14	15	22	18
11	6	7	9	5	7	15	8	9
12	3	1	2	1	3	4	2	2
13	17	10	9	11	3	5	4	17
14	20	27	22	21	21	15	19	19
15	12	9	9	14	11	12	9	12

APPENDIX G

TABLE 22

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 66 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	5	7	3	7	12
2	3	6	9	9	6
3	10	8	5	4	5
4	6	4	2	3	5
5	14	13	12	11	11
6	8	9	9	7	10
7	6	7	12	11	11
8	16	14	13	11	12
9	12	12	11	13	15
10	12	9	6	5	8
11	20	18	17	18	19
12	12	9	13	10	9
13	25	27	25	21	24
14	5	7	5	8	6
15	9	15	15	10	10

TABLE 23

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 66 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	9	3	2	3	4	8	8	3
2	4	4	3	4	8	5	6	6
3	6	3	6	8	6	6	2	2
4	5	5	3	5	4	5	3	5
5	7	5	6	7	4	9	8	10
6	5	11	14	11	10	9	9	8
7	11	6	10	12	13	9	11	9
8	15	7	2	3	3	2	7	4
9	8	13	9	11	12	17	12	11
10	3	2	2	3	6	5	9	10
11	12	19	17	15	15	10	18	20
12	14	8	5	2	8	5	1	3
13	16	17	15	17	15	20	16	12
14	5	2	5	6	8	4	8	7
15	5	5	6	8	8	11	13	11

TABLE 24

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 66 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	2	3	5	2	3	4	0	1
2	10	11	9	8	8	9	11	2
3	2	7	3	2	4	2	3	2
4	7	5	9	11	7	9	5	3
5	6	7	4	9	10	4	5	8
6	8	9	10	12	11	10	8	9
7	14	10	8	10	9	6	9	9
8	7	5	6	7	7	9	11	11
9	13	14	13	13	15	15	13	14
10	7	8	8	12	10	7	13	13
11	21	19	22	24	20	19	19	24
12	3	2	5	8	7	7	7	14
13	19	21	21	21	18	17	16	17
14	7	8	12	9	9	9	11	7
15	8	14	16	15	8	14	19	14

APPENDIX H

TABLE 25

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR ADAPTATION FOR 33 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10
1	2	4	5	5	8
2	15	14	11	10	14
3	15	13	11	16	9
4	7	7	7	4	8
5	14	9	7	8	10
6	29	17	18	14	12
7	10	8	7	8	6
8	20	18	18	22	13
9	5	6	4	3	7
10	7	5	6	11	7
11	17	13	13	17	14
12	27	22	22	21	22
13	9	11	17	13	16
14	15	14	11	4	8
15	15	15	10	6	6

TABLE 26

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR REINFORCEMENT FOR 33 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	7	6	10	7	7	9	7	8
2	13	8	7	6	1	2	3	8
3	14	9	11	10	13	14	9	11
4	4	7	4	6	2	3	5	3
5	5	5	4	3	3	1	0	2
6	14	13	15	10	12	9	7	8
7	8	6	8	12	8	12	6	14
8	9	13	7	8	8	7	10	9
9	3	4	5	7	4	2	4	2
10	7	6	8	7	7	12	12	9
11	14	10	10	11	11	9	10	10
12	30	28	22	19	28	19	24	21
13	9	12	11	12	13	12	7	12
14	2	5	6	8	8	10	9	2
15	11	5	7	5	7	4	7	7

TABLE 27

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR EXTINCTION FOR 33 PERCENT NONCONTINGENT SUBJECTS

S Number	2	4	6	8	10	12	14	16
1	4	5	8	8	6	10	5	9
2	4	2	7	5	9	6	8	10
3	11	11	11	11	12	12	12	16
4	7	4	3	9	11	9	6	7
5	3	0	1	2	0	2	3	4
6	11	15	12	13	12	14	12	11
7	9	13	10	11	9	11	18	10
8	12	11	8	10	5	8	13	9
9	4	5	2	6	3	3	4	6
10	14	15	14	18	18	13	11	18
11	13	9	13	22	20	17	11	20
12	20	24	25	20	17	21	22	24
13	14	11	11	9	14	11	13	12
14	5	8	7	10	6	12	12	4
15	7	6	7	7	5	8	6	11

APPENDIX I

TABLE 28

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR 1-10 MIN. FOR 0 PERCENT CONTROL SUBJECTS

S Number	2	4	6	8	10
1	3	7	5	4	4
2	6	6	6	3	7
3	7	5	5	5	7
4	11	15	13	8	6
5	3	2	2	2	4
6	19	15	17	19	20
7	15	11	16	18	18
8	14	15	12	14	11
9	14	8	5	3	8
10	15	13	13	16	10
11	11	11	12	16	12
12	11	9	6	6	7
13	15	11	11	6	11
14	12	5	6	7	6
15	15	13	10	13	15

TABLE 29

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR 11-26 MIN. FOR 0 PERCENT CONTROL SUBJECTS

S Number	12	14	16	18	20	22	24	26
1	3	4	2	6	5	8	1	2
2	5	5	7	7	10	8	6	11
3	9	11	8	8	7	4	9	6
4	5	10	9	7	7	6	5	6
5	2	7	7	2	7	8	3	2
6	11	17	15	14	13	15	14	13
7	17	20	18	13	18	21	14	23
8	14	12	14	16	13	8	10	11
9	7	8	6	8	8	7	6	9
10	12	12	12	13	10	12	11	10
11	11	9	14	11	12	9	8	10
12	11	7	9	13	7	8	9	9
13	6	6	2	6	7	4	4	5
14	13	11	13	14	13	9	12	9
15	18	11	14	16	14	11	13	14

TABLE 30

NUMBER OF RESPONSES PER 2-MIN. BLOCK FOR 27-42 MIN. FOR 0 PERCENT CONTROL SUBJECTS

S Number	28	30	32	34	36	38	40	42
1	3	4	6	4	5	7	8	5
2	6	10	12	11	11	12	12	5
3	16	9	9	10	10	11	12	5
4	4	3	8	5	2	3	2	4
5	5	7	5	8	6	8	7	7
6	18	9	14	13	12	13	17	15
7	18	19	14	13	13	13	16	18
8	12	12	12	9	13	9	8	8
9	7	3	6	5	3	1	1	2
10	14	12	10	3	4	6	10	9
11	9	12	11	13	10	18	14	14
12	10	14	7	7	8	8	7	4
13	1	9	5	7	5	7	4	2
14	14	11	9	5	5	7	10	11
15	19	9	10	9	12	6	6	11

APPENDIX J

TABLE 31

MEANS AND STANDARD DEVIATIONS OF THE NUMBER OF RESPONSES FOR EACH GROUP DURING ADAPTATION (IN 2-MIN. BLOCKS)

Group		1	2	3	4	5
Contingent						
100	$\bar{X}$	11.5	10.5	11.2	10.1	11.4
	SD	7.0	5.4	6.3	4.8	6.0
66	$\bar{X}$	12.1	9.9	9.5	9.5	11.2
	SD	6.8	4.7	6.1	4.7	5.1
33	$\bar{X}$	13.4	10.9	10.8	9.0	8.9
	SD	7.3	6.2	6.6	5.8	4.1
Noncontingent						
100	$\bar{X}$	11.5	10.5	12.5	11.0	11.1
	SD	5.7	5.9	6.8	6.6	7.5
66	$\bar{X}$	10.5	11.0	10.5	9.9	10.9
	SD	5.9	5.6	5.8	4.7	5.1
33	$\bar{X}$	13.8	11.7	11.1	10.8	10.7
	SD	7.3	5.0	5.3	6.0	4.3
0	$\bar{X}$	11.4	9.7	9.3	9.3	9.7
	SD	4.6	4.0	4.4	5.8	4.7

TABLE 32

MEANS AND STANDARD DEVIATIONS OF THE NUMBER OF RESPONSES
FOR EACH GROUP DURING ACQUISITION
(IN 2-MIN. BLOCKS)

Group		1	2	3	4	5	6	7	8
Contingent									
100	$\overline{X}$	7.3	8.5	8.6	8.8	8.3	9.0	8.0	9.2
	SD	3.7	4.7	3.7	4.0	4.2	4.5	4.0	4.3
66	$\overline{X}$	8.5	8.9	8.0	9.1	9.2	9.5	9.3	8.8
	SD	3.8	3.7	4.1	4.2	4.5	4.0	3.9	4.8
33	$\overline{X}$	10.1	8.3	8.3	7.9	8.7	7.9	8.1	7.8
	SD	4.8	4.5	4.0	3.3	4.0	4.4	3.5	3.7
Noncontingent									
100	$\overline{X}$	7.9	7.9	7.3	7.1	8.2	7.2	6.5	5.7
	SD	4.9	4.0	5.6	4.2	5.5	6.4	5.2	5.4
66	$\overline{X}$	8.3	7.3	7.0	7.7	8.3	8.3	8.4	8.1
	SD	4.1	5.2	4.8	4.5	3.9	4.7	4.9	4.5
33	$\overline{X}$	10.0	9.1	9.0	8.7	8.8	8.3	8.0	8.4
	SD	6.6	4.5	4.5	3.7	6.3	5.0	5.2	5.0
0	$\overline{X}$	9.6	10.0	10.0	9.6	10.0	9.2	8.3	9.3
	SD	4.7	4.2	4.6	3.9	3.5	4.2	4.0	5.0

TABLE 33

MEANS AND STANDARD DEVIATIONS OF THE NUMBER OF RESPONSES
FOR EACH GROUP DURING EXTINCTION
(IN 2-MIN. BLOCKS)

Group		1	2	3	4	5	6	7	8
Contingent									
100	$\bar{X}$	10.1	9.8	9.8	10.7	9.7	8.7	9.7	9.0
	SD	5.9	5.1	4.8	4.7	4.2	3.5	4.9	4.2
66	$\bar{X}$	11.1	10.7	9.3	10.4	9.9	10.7	12.5	8.3
	SD	6.5	5.8	6.0	6.0	5.5	5.9	8.0	4.5
33	$\bar{X}$	10.1	9.1	8.6	8.8	9.8	9.3	8.8	8.9
	SD	4.0	3.7	2.8	4.2	4.7	4.4	2.9	3.1
Noncontingent									
100	$\bar{X}$	9.8	8.3	10.1	8.7	8.6	8.6	9.0	8.9
	SD	7.3	7.2	6.4	6.6	5.6	5.4	6.8	6.3
66	$\bar{X}$	8.9	9.5	10.0	10.9	9.7	9.4	10.0	9.9
	SD	5.5	5.3	5.6	5.7	4.6	4.8	5.4	5.3
33	$\bar{X}$	9.2	9.3	9.3	10.7	9.8	10.5	10.4	11.4
	SD	4.8	5.9	5.6	5.4	5.6	4.8	5.1	5.6
0	$\bar{X}$	9.7	9.5	9.2	8.1	7.9	8.6	8.9	8.0
	SD	5.9	4.1	2.9	3.3	3.7	4.1	4.6	4.7

BIOGRAPHICAL SKETCH

William Albert Greene was born September 13, 1934, in San Diego, California. In June, 1952, he was graduated from Point Loma High School. In August, 1956, he received the degree of Bachelor of Arts from San Diego State College. From 1957 until 1960 he served in the Army Security Agency of the United States Army and was stationed in Germany. Following his discharge from the Army, he enrolled in the Graduate School of San Diego State College. He worked as a research and teaching assistant until August, 1961. He received the Master of Science degree from San Diego State College in June, 1963. From September, 1961, until the present time he has pursued his work at the University of Florida toward the degree of Doctor of Philosophy.

William Albert Greene is married to the former Jean Lynell Hunt and is the father of one child. He is a member of Psi Chi and the Psychometric Society.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of that committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council, and was approved as partial fulfillment of the requirements for the degree of Doctor of Philosophy.

August 8, 1964

Dean, College of Arts and Sciences

Dean, Graduate School

Supervisory Committee:

Chairman